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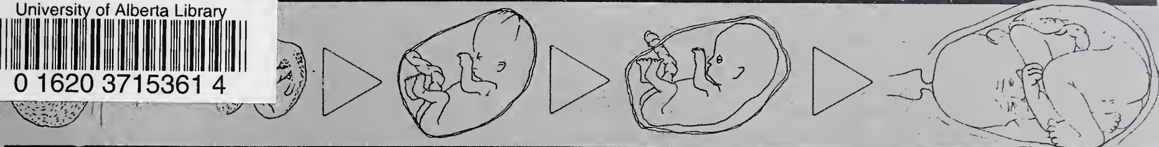
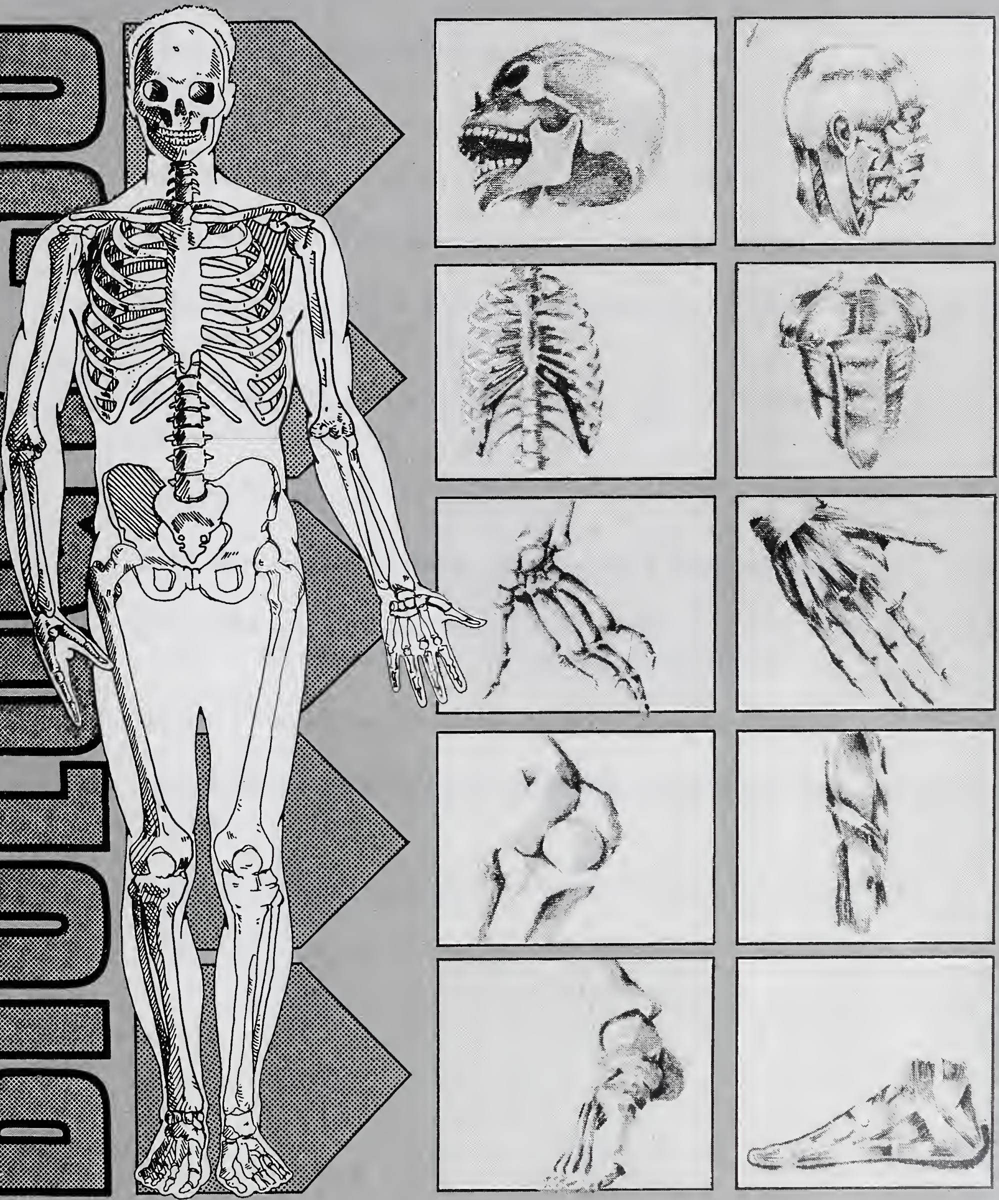


BIOLOGY 30



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OBJECTIVES

After studying this lesson the student should be able to:

1. **List** the two major components of blood.
2. **Define** serum.
3. **Describe** the composition and function of a red blood cell.
4. **Understand** how oxygen concentration is related to erythrocyte production.
5. **Describe** the major types of granular and non-granular leukocytes, as well as their importance in fighting disease organisms.
6. **Write** a brief description of the following disorders: leukemia, mononucleosis, hemophilia and anemia.
7. **Describe** the structure of a platelet.
8. **Show**, using simple formulas or diagrams, how a blood clot forms.
9. **Understand** how the composition of the four common blood types - A, B, O and AB - relates to the presence or absence of antigens and antibodies.
10. **Explain** the importance of accurate matching in blood transfusions.
11. **Understand** the Rh factor and its importance during pregnancy or during a blood transfusion.
12. **Outline** the major components of the lymphatic system and their functions.
13. **Define** edema and give an example.

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BLOOD STRUCTURE AND FUNCTION

Introduction

The circulatory system in human beings is responsible for the **transport** of oxygen, nutrients and metabolites to cells, and for carrying carbon dioxide and other wastes away from cells. The thin capillary walls form the barrier between the interstitial fluid surrounding the cells and the blood flowing in the capillaries. **Blood** plus a secondary circulatory system, the **lymphatic system**, insure that the overall composition of the body remains adjusted within fairly narrow limits so that **homeostasis** is maintained.

The composition of our blood is constantly renewed as it circulates through the various body organs. The heart pumps the blood through the blood vessels which take blood to the capillaries and back again to the heart (refer to Lesson 9 for more details). In the capillaries of the **lungs**, blood picks up oxygen and gives off carbon dioxide (refer to Lesson 8). In the capillaries of the **digestive tract**, the blood picks up nutrients (discussed in Lesson 5). This blood is then filtered in the capillaries of the **liver**, and the nutrient content of the blood can be adjusted and controlled. Blood is also filtered in the capillaries of the **kidneys**, where wastes are removed and the overall composition of the blood is adjusted (see Lesson 14).

As well as transport, the blood also helps to regulate body **temperature** and the **pH** of body fluids, and plays a role in **fighting disease**. This lesson looks at the structure and function of the blood and the lymphatic system.

Characteristics of the Blood

READ

Read the sections of your text dealing with the components of the blood (pp. 212 - 218).

If you weigh 70 Kg, your body contains about 5.6 litres of blood, of which 55% is a straw-coloured watery fluid called **plasma**. The specialized cells of the blood are suspended within the plasma.

Plasma

Plasma contains many organic and inorganic substances dissolved or suspended in it; e.g. nutrients and wastes. These are added as it passes through the various organs as outlined in the introduction of this lesson. A number of special proteins are found in blood plasma which aid in maintaining osmotic pressure, clotting blood and producing antibodies to fight infection. **Serum** is plasma which has the proteins involved in blood clotting removed.

Blood Cells

The blood cells may be divided into three main groups:

A. Red Blood Cells or Erythrocytes
B. White Blood Cells or Leukocytes
C. Platelets

A. Red Blood Cells

Red Blood Cells (erythrocytes) are the most numerous cells in the blood. Their main function is to transport gases, and they are highly specialized to do so. Mature red blood cells have **no nuclei** and very little internal structure. Instead, they contain **hemoglobin**- a protein with attached iron molecules which can carry oxygen and carbon dioxide.

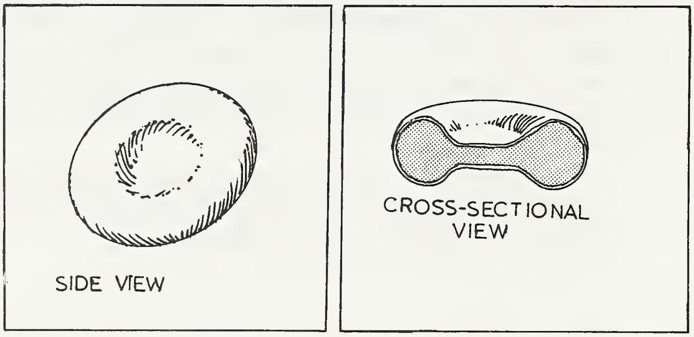


Figure 1: Red Blood Cells

Erythrocytes are produced in bone marrow and have a nucleus. When they enter the bloodstream they lose their nucleus and assume an active life of about 120 days before they break up and are destroyed.

The **production** of red blood cells is carefully regulated. If the red blood cell population falls, the bone marrow immediately increases production. **Oxygen concentration** is the key factor regulating red blood cell production. If you lead a **physically active** life which requires a large supply of oxygen for cellular respiration, erythrocyte production is increased to meet the body's needs.

Another situation where the body demands an increased amount of oxygen is when you are living at **high altitudes**. At high altitudes the air pressure is lower than at sea level and there is less air available to breathe. People who visit high altitude areas can overcome this by increasing their breathing rate. For example, it took Olympic athletes at the 1978 Mexico Olympics about three weeks to adapt to the altitude change. People who live and die at such altitudes are born with a number of adaptations including a larger number of red blood cells. Their blood contains more hemoglobin so that it can transport more oxygen.

Anemia is a condition in which the blood contains fewer erythrocytes or less hemoglobin than usual as a result of either slow production or fast destruction of the red blood cells. Anemia is a symptom which may be the result of a number of diseases.

B. White Blood Cells

White Blood Cells (Leukocytes) function chiefly to defend the body against invaders such as; viruses, bacteria and other foreign particles. There is only about one white blood cell for every 600 red blood cells. White blood cells contain nuclei and can be divided into two major groups - **granular** white cells with large staining granules in the cytoplasm (neutrophils, basophils and eosinophils) and **non-granular** white cells with a central nucleus and no granules in the cytoplasm (lymphocytes and monocytes).

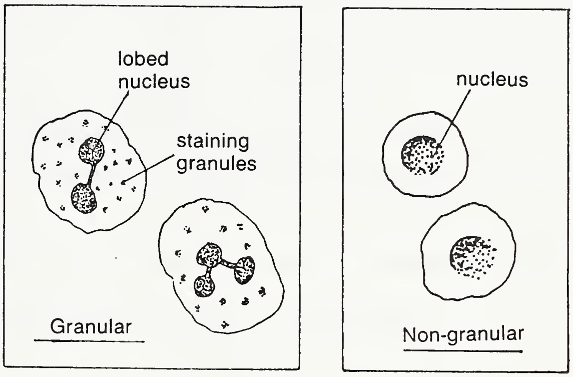


Figure 2: White Blood Cells

White blood cells help defend the body in two ways:

1. By taking part in the manufacture of special protein substances known as **antibodies** which combine with foreign particles and disease-causing agents and inactivate them.

2. By **phagocytosis**. The foreign substance is trapped by the flexible pseudopodia, incorporated into a food vacuole and destroyed by enzymes from the lysosome.

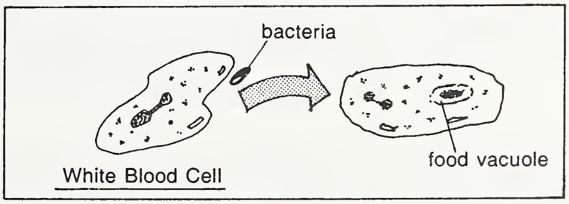


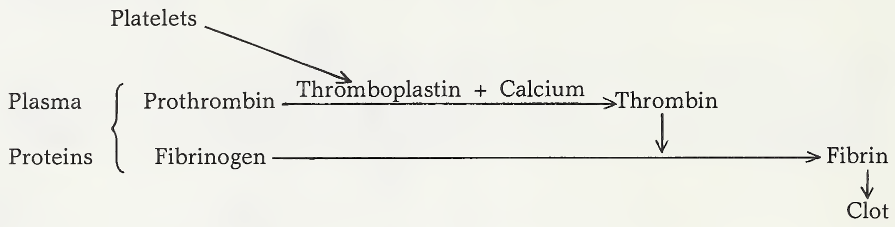
Figure 3: Phagocytosis

White blood cells are often destroyed in the course of fighting infection. **Pus** is composed mostly of white blood cells. New cells are formed in the spleen and bone marrow.

There are a number of white blood cell disorders. **Please consult your textbook (page 217) for a brief discussion of leukemia and mononucleosis.**

C. Platelets

Platelets initiate blood clotting. When the wall of a blood vessel is damaged or broken, the injured cells release a substance which attracts blood platelets to the site. Platelets are really fragments of larger cells which can release a substance called **thromboplastin**. The release of this substance starts a chain reaction which will eventually lead to the formation of a plug or **clot** which seals off the injured part of the blood vessel and prevents the loss of blood.



Hemophilia is a rare blood disorder which prevents normal blood clotting.

Exercise 1

Circle whether the following statements are True (T) or False (F).

T F 1. Serum is plasma with red blood cells removed.

T F 2. Mature red blood cells contain no nuclei.

T F 3. Both oxygen and carbon dioxide are carried by hemoglobin.

T F 4. Carbon monoxide binds to hemoglobin better than oxygen.

T F 5. A person living in a high mountain village would have fewer red blood cells than someone living in the valley.

T F 6. Anemia is always an inherited disease.

T F 7. All white blood cells contain nuclei.

T F 8. Lymphocytes and monocytes lack granules and nuclei.

T F 9. White blood cells never carry gases.

T F 10. Leukocytes are usually formed in the bone marrow.

T F 11. The process of surrounding an invading bacteria with pseudopodia is called active transport.

T F 12. Antibodies are special proteins which immobilize foreign bodies.

T F 13. Persons suffering from leukemia produce too many immature white blood cells.

T F 14. Mononucleosis is caused by a virus.

T F 15. The substance released by platelets is called fibrinogen.

T F 16. Thrombin plus fibrinogen produces the blood clotting material.

T F 17. Plasma carries urea to the kidneys.

T F 18. Homeostatic heat control is maintained by the movement of blood.

Please check your work with the answers given on pages 9 and 10.

Blood Types

READ

Read the sections of your text dealing with blood types and blood typing (pp. 218 - 221).

A. ABO Groups

There are **four** basic blood groups or types found in man. The blood types are named A, B, AB and O according to the presence or absence of two **proteins** - **antigen A** and **antigen B** - found in the **red blood cells**. A person with **Type A** blood contains antigen A in their red blood cells while a person with **Type B** blood contains antigen B in their red blood cells. Both antigen A and antigen B are found in people of **Type AB** and both are absent in blood **Type O**.

As well as antigens, two other proteins known as **antibody a** and **antibody b** may be found in the **blood plasma**. Consult the following chart for the presence of antigens and antibodies in the different blood types.

BLOOD TYPE	ANTIGENS and ANTIBODIES PRESENT
Type A blood	A antigens and b antibodies
Type B blood	B antigens and a antibodies
Type AB blood	AB antigens and no antibodies
Type O blood	no antigens and ab antibodies

It is important to match the correct types of blood carefully when blood transfusions are made or the blood cells will become sticky (agglutinate) and become useless. Agglutination will occur if blood containing antigen A is mixed with blood containing antibody a. This would happen if Type A blood were mixed with Type B blood. Type A blood would also clot if Type AB blood were mixed with it.

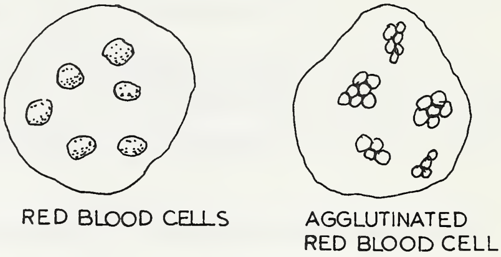


Figure 4: Agglutination

B. Rh Factor

About 60 other blood groupings besides the ABO blood factors are known to exist in the plasma, but these are so weakly antigenic that they do not cause any problems in transfusions. The blood Rh factor, however, is important.

About 85% of the North American population carries the **Rh antigen** in its red blood cells. These people are said to be Rh positive (Rh^+). The remaining 15% of the population lack the Rh antigen and are Rh negative (Rh^-). The blood of an Rh negative person does not usually carry antibodies for the Rh factor. Antibodies will develop, however, in an Rh negative person if they receive Rh positive blood. The first blood transfusion would cause no problems because antibodies are just being built up. By a second or third transfusion, however, the antibodies may be a factor and the Rh positive blood cells of the donor may be agglutinated by antibodies present in the Rh negative recipient.

The Rh factor may also be a problem during pregnancy if the mother is Rh negative and both the father and the fetus are Rh positive. The first pregnancy would probably have no complications except that the mother would build up Rh antibodies. The Rh antibodies are produced in response to Rh positive blood cells which seep into the mother's bloodstream via the placenta. In a subsequent pregnancy, the Rh antibodies already in the mother's bloodstream would cross the placenta and enter the fetal circulatory system. Once in the fetal circulatory system, the antibodies destroy the Rh^+ fetal blood cells.

Exercise 2

1. A person with Type A blood contains ________ antigens and ________ antibodies.
2. A person with Type B blood contains ________ antigens and ________ antibodies.
3. Someone with no antigens is Type ____________.
4. Someone with no antibodies is Type ____________.
5. Should someone with Type O blood donate blood to someone with Type A blood? Explain.

   ____

   ____

   ____

   ____

6. What is the Rh factor?

   ____

   ____

   ____

Please check your work with the answers give on page 10.

Lymph and the Lymphatic System

Read the section of your textbook entitled "The Lymphatic System" (pp. 245 - 247).

The lymphatic system acts as an auxilliary circulatory system to the blood. Its major function is to return any excess interstitial fluid and proteins to the circulatory system. At the lymph nodes it also functions as part of the immune system against disease.

The lymphatic system consists of blind-ended capillaries which connect up into ever larger vessels, ending in a vein near the heart. These vessels drain interstitial fluid from tissues both near the surface and in the interior of the body.

This fluid (now called **lymph**) enters the circulatory system through large veins in the neck and upper thorax region. The **thoracic duct** collects lymph from most of the body and empties it into the **left subclavian vein**. The right lymphatic duct empties into the **right subclavian vein** and collects lymph from the upper right half of the torso.

See the diagram on page 317 of your text which shows the relationship between the lymphatic vessels and the capillary network of the arteries and veins in an intestinal villus.

In a situation where the lymphatic system is unable to return excess interstitial fluid to the bloodstream, a state of **edema** may result. You have probably noticed this in yourself after sitting still or standing motionless for a long time, as a swelling of your feet and ankles. Blood accumulates in the legs and ankles and cannot return to the heart as a result of increased capillary pressure and a lack of muscle movement to move the fluids along. This type of edema is localized and reversible once blood starts flowing again towards the heart. Other types of edema caused by liver damage, starvation or infection may be more serious.

Lymph nodes

Lymph nodes appear at intervals along the larger lymphatic vessels and function to produce:

1. lymphocytes.

2. plasma cells, which are the source of antibodies.

3. macrophages, which surround and destroy invading micro-organisms.

Macrophages in the lymph nodes form a second line of defense, preventing bacteria from entering the blood. If you have a fever and general malaise, a doctor will often check to see if the lymph nodes behind your ears, under your jaw, under your armpits or in your tonsils are swollen. Swollen lymph nodes indicate that your lymphatic system is fighting infection.

Exercise 3

1. The major function of the lymphatic system is to return excess ______________ and ______________ to the circulatory system.

2. The ______________ duct collects lymph from most of the body and empties it into the ____________ subclavian vein. The right lymphatic duct empties into the ______________ subclavian vein.

3. Failure to return excess fluids to the circulatory system may result in a local or generalized swelling known as ______________.

4. Lymph nodes produce ______________, ______________, and plasma cells that produce ______________ .

Please check your work with the answers give on page 10.

ANSWERS TO THE KEYED EXERCISES

Exercise 1, p.4.

True or False Questions

1. **False.** Serum is plasma with the proteins involved in blood clotting removed.
2. **True**
3. **True**
4. **True**
5. **False.** People living at high altitudes would have **more** red blood cells than those persons living at lower altitudes.
6. **False.** Anemia may be caused by a number of diseases.
7. **True.**
8. **False.** Lymphocytes and monocytes lack granules but they do possess nuclei.
9. **True.**
10. **True.**
11. **False.** The process of surrounding invading bacteria with pseudopodia is called **phagocytosis.**

12. **True.**

13. **True.**

14. **True**

15. **False.** Each platelet is filled with the substance **thromboplastin.**

16. **True**

17. **True**

18. **True.**

Exercise 2, p.7.

1. A person with Type A blood contains **A** antigens and **b** antibodies.

2. A person with Type B blood contains **B** antigens and **a** antibodies.

3. Someone with no antigens is Type **O** .

4. Someone with no antibodies is Type **AB** .

5. Could someone with Type O blood donate blood to someone with Type A blood? **Yes.** Explain.

   Type O blood has no antigens to clot with antibodies in Type A blood.

6. What is the Rh factor?

   Rh factor is an antigen found in red blood cells.

Exercise 3, p.8.

1. The major function of the lymphatic system is to return excess **fluid** and **proteins** to the circulatory system.

2. The **thoracic** duct collects lymph from most of the body and empties it into the **left** subclavian vein. The right lymphatic duct empties into the **right** subclavian vein.

3. Failure to return excess fluids to the circulatory system may result in a local or generalized swelling known as **edema**.

4. Lymph nodes produce **lymphocytes, macrophages,** and plasma cells that produce **antibodies**.

EXERCISES TO BE SENT IN FOR CORRECTION

Exercise 1 - Components of Blood

Part One: Matching

1. Match the following structures with the functions they perform.

________ Site of formation of red blood cells

________ Proteins found on the surface of red blood cells.

________ Site of filter that removes foreign particles from body fluid.

________ White blood cell which engulfs invading micro-organisms.

________ Particles that produce clotting enzymes.

A. Lymph Node
B. Spleen
C. Antigen
D. Antibody
E. Bone Marrow
F. Eosinophil
G. Thymus gland
H. Platelet

Part Two: Multiple Choice

For each of the following questions, choose the best answer and write the appropriate letter in the blank provided.

________ 1. The greatest amount of oxygen will be lost from blood which is travelling through:

(a) capillaries around the alveoli.
(b) the left atrium of the heart.
(c) the arteries.
(d) the capillaries in the body.
(e) the veins.

________ 2. Which does **not** belong?

(a) erythrocytes
(b) neutrophils
(c) lymphocytes
(d) monocytes

________ 3. Capillaries on the surface of the small intestine pick up a lot of

(a) oxygen.
(b) nutrients.
(c) urea.
(d) carbon dioxide.

________ 4. Red blood cell production is **most directly** affected by

(a) the amount of extracellular fluid.
(b) the amount of oxygen in the blood.
(c) the amount of carbon dioxide in the blood.
(d) too many waste salts in the blood.

________ 5. A disease condition which results in the formation of too many immature white blood cells is

(a) anemia.
(b) leukemia.
(c) mononucleosis.
(d) hemophilia.

________ 6. Protein substances which inactivate foreign particles in the body are called

(a) antigens.
(b) agglutinens.
(c) antibodies.
(d) platelets.

________ 7. A plasma protein important in blood clot formation is

(a) calcium.
(b) antibodies.
(c) antigen.
(d) fibrinogen.

________ 8. Nongranular leucocytes do **not** have

(a) a nucleus.
(b) cytoplasmic granules.
(c) hemoglobin.
(d) two of the above

Part Three: Short Answer Questions

1. What is the difference between serum and plasma?

____

____

2. Of what advantage is the shape of the erythrocyte?

____

____

____

3. Why is carbon monoxide (CO) such a lethal gas?

____

____

____

4. List the two methods the body uses to fight invasion by bacteria or viruses.

(a) ____

(b) ____

Exercise 2 - Blood Types and Typing

Part One: Fill in the Blanks

1. Blood types are dependent upon the kind of __________ found in the __________ __________ cells. A person with Type A blood has A __________ in his cells while someone with Type AB blood would have antigens ______ and ______ .

2. Antibodies are also found in blood ________ . Type A blood contains ______ type antibodies and Type B blood contains ______ type antibodies. Type O blood contains ______________ antibodies.

3. Fill in the following Chart of Blood Types and Typing.

Blood Type	Antigen In Corpuscles	Antibodies In Plasma	Can Donate To	Can Receive From
A	A	"b"		
B	B	"a"		
AB	A and B	none		
O	none	"a" and "b"		

Part Two: Short Answer Questions

1. Why is someone with Type O blood called a "universal donor"?

2. Why can someone with Type AB blood receive blood from anyone?

3. What is the Rh factor?

4. Why does the Rh factor only become a problem in transfusions or pregnancies, the **second** time an Rh negative (Rh–) person is exposed to Rh positive (Rh+) blood.

5. What must be the Rh factor makeup of the mother, father and fetus in order for the Rh factor to become a problem during pregnancy?

Exercise 3 - Lymphatic System

1. What are the two major functions of the lymphatic duct system?

(a) __________

(b) __________

2. The lymphatic system from most of the body rejoins the circulatory system through which duct? Into which major vein(s) does this empty?

3. Briefly define **edema**.

4. Why is checking for swollen lymph nodes a normal part of a physical examination?

Please submit pages 11 to 15 for correction.

END OF LESSON 10

BIOLOGY 30

Lessons 11-20

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(3) Your work has been re-read to ensure accuracy in spelling and lesson details.
(4) The Lesson Record Form is filled out and the correct lesson label is attached.
(5) This mailing sheet is placed on the lesson.

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Do **not** enclose letters with lessons.

Send all letters in a separate envelope.

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Take your lesson to the Post Office and have it weighed. Attach sufficient postage and a **green first-class sticker to the front of the envelope, and seal the envelope. Correspondence lessons will travel faster if first-class postage is used.**

Try to mail each lesson as soon as it has been completed.

When you register for correspondence courses, you are expected to send lessons for correction regularly. Avoid sending more than two or three lessons in one subject at the same time.

OBJECTIVES

By the end of Lesson 11, the student should be able to:

1. **Describe** the parts and functions of a typical neuron.
2. **Distinguish** between ''white matter'' and ''grey matter''.
3. **Describe** the electrochemical nature of a nerve impulse.
4. **Define** and **describe** the function of a synapse.
5. **Describe** and **explain** how certain chemicals aid in transmission of nerve impulses.
6. **Describe** the structure and function of the major areas of the central nervous system.
7. **Discuss** the major areas of the brain and what activities these parts control.
8. **Explain** how the central nervous system is protected by the skeleton, meninges, and cerebrospinal fluid.
9. **Describe** the pathway of a motor neuron and a sensory neuron to and from the spinal cord.
10. **Understand** the functions of the various parts of a reflex arc.
11. **Outline** the parts and functions of the autonomic nervous system.

CENTRAL NERVOUS SYSTEM

Introduction

Human survival depends upon receiving and interpreting information about changes which are occurring both outside and inside the body. The **nervous system** and the **endocrine system** are the two major control systems involved. Any change (or impending change) to the body's environment automatically initiates a chain of events which wipe out the change, or set the body in a state of readiness so it can deal with the change.

Some parts of the nervous system serve the systems which achieve homeostasis, maintain posture, stimulate glands to secrete and change muscle tension to maintain balance. Neural activity also accounts for such subjective experiences as thoughts, dreams, ideas, sensations, emotions and memories.

In this lesson you will be introduced to the major structures and functions of the **central nervous system, peripheral nervous system** and **autonomic nervous system.** Nerve impulses in all these systems are carried by nerve cells or **neurons**. The electrochemical nature of the **nerve impulse** will also be studied.

Structure of the Neuron

READ

Read the textbook section entitled "Neuron" (pp. 136 to 138).

The basic unit of the nervous system is the **neuron**. Other cells called **glial** cells are present in large numbers for nurture and support. Neurons are such specialized cells that they cannot be replaced. Those we are born with must last us throughout life. Some axons may be replaced if they are covered with a specialized **neurilemma**. Study Figure 1 to locate the important structures in a neuron.

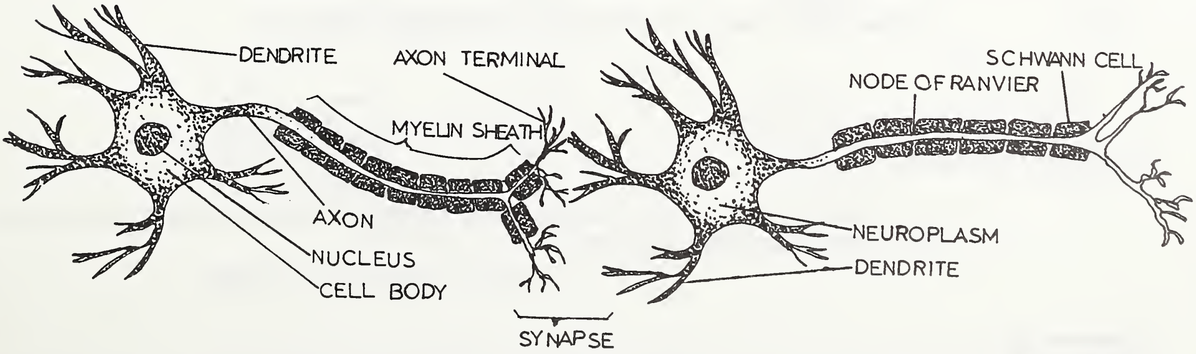


Figure 1: Structure of motor neurons (note the synapse).

Most neurons are invisible to the naked eye. What we usually call a **nerve** consists of a bundle of axons bound together like wires in a cable. The axons are often insulated for better conduction of neural impulses just as wires are insulated for the faster conduction of electricity.

Insulation of axons takes the form of a fatty covering called the **myelin sheath** which is derived from the cell membrane of **Schwann cells**. The spaces between the Schwann cells are called **nodes of Ranvier** and are the site of local circuits along the axon.

Myelinated axon fibres make up the **"white matter"** of the nervous system. If people tell you to use your **"gray matter"** they are really referring to unmyelinated axon fibres and nerve cell bodies of the central nervous system.

Exercise 1

Fill in the blanks.

1. Nerve cell projections which conduct impulses towards the nerve cell body are called ____________________.
2. Nerve cell projections conducting impulses away from the nerve cell body are called ____________.
3. Axons may be insulated with a fatty __________ sheath, produced by __________ cells.
4. Some axons may be repaired due to the presence of a ____________________.
5. "White matter" consists mostly of ______________________________.
6. "Gray matter" consists mainly of ____________________ and ____________________.

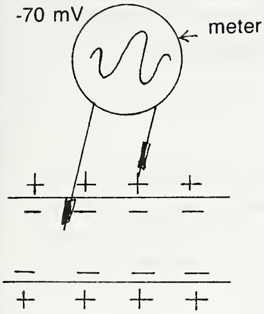
Please check your work with the answers given on page 13.

Function of the Neuron

All activity of the nervous system depends upon the **conduction** of impulses along axons and their **transmission** from one neuron to the next.

Read the sections of your text dealing with the transmission of the nerve impulse (pp. 138 to 141).

Conduction of Nerve Impulses



Resting Potential of an Axon

The conduction of nerve impulses is accompanied by electrical changes. In experiments with axons, there was a measurable electric current flow between the inside and the outside of the axon. Surrounding the axon there are many positively and negatively charged ions present. If these ions become unequally distributed, an electrical **potential difference** results between the two regions.

In an unstimulated neuron, the inside is negatively charged with respect to the outside. A potential difference of -70 mV (millivolts) exists across the membrane. This is called the **resting potential** and the axon is said to be **polarized**.

The origin of this polarization is due to the unequal distribution of ions on the two sides of the membrane. Positively charged sodium ions (Na^+) are held outside the axon membrane by the selectively permeable membrane. Potassium ions (K^+) and chloride ions (Cl^-) can move freely across the membrane at rest. Chloride ions (Cl^-) and negatively charged organic molecules maintain a negative charge on the inside of the membrane.

Action Potential

When a stimulus is given to an axon, the potential changes from -70 mV to +20 mV and is referred to as **depolarization**. In about 1/1000 of a second, the membrane is repolarized to its resting potential of −70 mV. The complete cycle is called an **action potential**.

The change from a resting potential to an action potential is due to the movement of ions through the membrane. The membrane becomes temporarily permeable to sodium ions (Na^+). Sodium ions rush in and the membrane becomes positive compared to the outside. When a peak of about +20 mV is reached the membrane again becomes impermeable to sodium and the ions become redistributed by active transport to reestablish the resting potential. (See Figure 2).

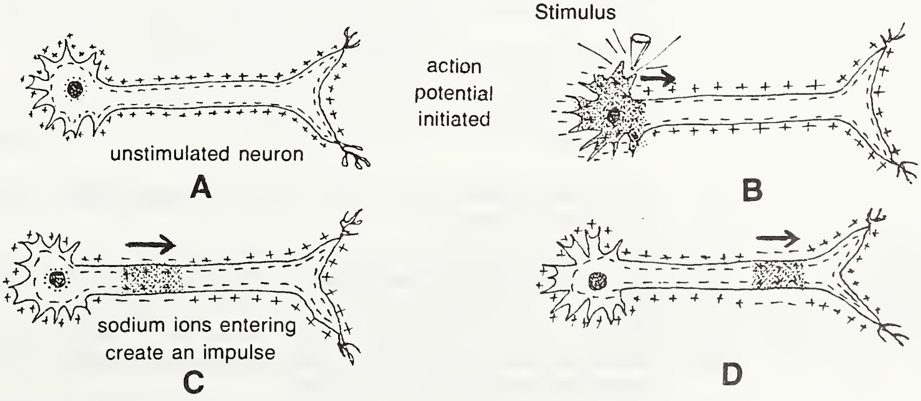

Stimulus
action potential initiated
unstimulated neuron
A
B
sodium ions entering create an impulse
C
D

Figure 2: The Action Potential

A. Refractory Period

A membrane must always be at resting potential before it can be stimulated to produce an action potential. Therefore, there is a brief pause between action potentials while the membrane is repolarized. This is called the **refractory period.**

B. Initiation of an Impulse

In order for an action potential to start moving along an axon, the membrane must be depolarized to a critical firing level called the **threshold level**. Stimuli may be in the form of light (eye), pressure (touch), sound (ear), or chemical (taste). If the stimulus received is too weak it is said to be subthreshold. A threshold level is necessary to get the action potential moving along the axon.

C. "All-or-None" Response

If you increase the strength of the stimulus beyond the threshold level, you will **not** increase the size of the action potential. The action potential is always of the same size. Action potentials are said to be **"all-or-none"** in their response.

Exercise 2

Circle the correct letter, **T** or **F**, to indicate whether the statement is True or False.

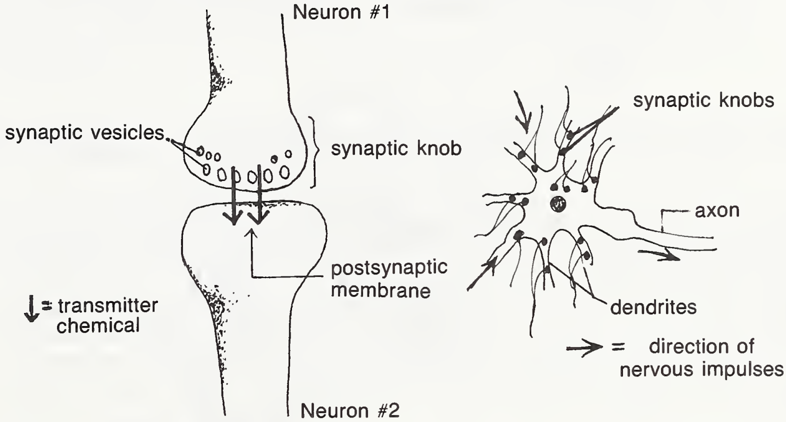
1. There is an electrical difference between the inside and outside of a resting axon membrane. T F
2. The potential difference between the inside and outside of a membrane is due to ion distribution. T F
3. Potassium ions (K^+) are located primarily on the outside of an axon. T F
4. Sodium ions (Na^+) are located on the outside of an axon. T F
5. An unstimulated membrane has a positive charge outside compared to the inside. T F
6. An action potential is the result of depolarization and Na^+ ions moving across the membrane. T F
7. The repolarization of a membrane is reestablished by simple diffusion of ions. T F
8. During an action potential there is a positive charge on the outside of the membrane compared to the inside. T F
9. The "all-or-none" response refers to the threshold potential of an axon. T F
10. The "refractory period" refers to the time between stimuli given to a nerve. T F

Please check your work with the answers given on page 14.

Transmission of Nerve Impulses

There is no direct physical connection between the thousands of nerves in our body. There is a junction called a **synapse** between the end of an axon of one neuron and the dendrite or cell body of the next neuron. The contact between them is made by **chemical transmitter substances** across the synaptic gap. These substances may stimulate or inhibit the firing of the next neuron.

Please refer to Figure 3 to assist you with the following description. When impulses arrive at the end of a transmitting neuron, a chemical transmitter is released from vesicles and becomes attached to receptor sites on the postsynaptic neuron. The postsynaptic knob becomes depolarized and an action potential is initiated in the next neuron. Usually, the quantity of the transmitter substance released from one neuron is too small to initiate firing in the postsynaptic neuron. Instead, several neurons release transmitter substances to cause depolarization.



Synapse

Synaptic Junctions

Figure 3: Function of the Synapse

Transmitter Substances

A. Acetylcholine

Acetylcholine is released at synapses in the central and autonomic nervous systems and at the junction between the nerve and skeletal muscle. Shortly after it is released it is destroyed by the enzyme **cholinesterase** (acetylcholinesterase). The postsynaptic neuron then stops firing. If the neuron kept on firing the nervous system would run wild, causing uncontrollable tremors, spasms and perhaps death.

B. Noradrenalin

Noradrenalin (norepinephrine) is also a chemical transmitter substance. It is released by some parts of the autonomic nervous system (see the latter part of this lesson).

One-Way Transmission

A nerve impulse is propagated and travels in only one direction across a synaptic gap because only the presynaptic side of the synapse can release the chemical transmitter and only the postsynaptic membrane has receptor sites. This one-way transmission increases the efficiency of the transmission of impulses over long distances.

Inhibitory Synapses

Not all synapses are excitatory as described above. Certain transmitter substances have been shown to inhibit the transmission of impulses on the postsynaptic neuron. The postsynaptic neuron does not bcome sufficiently depolarized to fire action potentials. Antagonistic muscle groups offer a simple demonstration of the use of this inhibitory response (see Lesson 7). e.g. When the biceps (flexor muscles) are stimulated to contract by excitatory synapses, the triceps (extensor muscles) receive an inhibitory stimulus which results in their relaxation. As a result we are able to bend our arm.

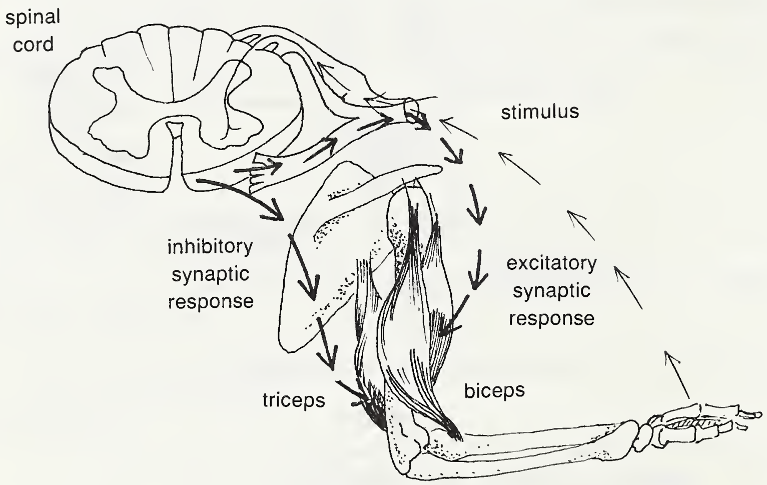


Figure 4: Synaptic Responses and Muscle Contraction

Exercise 3

Circle the correct answer.

1. The neurons of the nervous system (do/do not) make physical contact.
2. Chemical transmitters are released from synaptic vesicles found in the (presynaptic/postsynaptic) neuron.
3. Chemical transmitters like acetylcholine cause the (depolarization/repolarization) of the postsynaptic membrane.
4. Action potentials are fired when (sodium ions/potassium ions) enter the dendrites of the receiving neuron.

5. Sufficient depolarization is usually affected when (one/several) synaptic knobs fire.
6. Acetylcholine must be destroyed by (cholinesterase/noradrenalin) to prevent runaway firing of the postsynaptic neuron.
7. A nerve impulse is transmitted (one way/both ways) across a synaptic gap.
8. Some synapses may prevent firing of a postsynaptic neuron and are called (inhibitory/refractory) synapses.

Please check your work with the answers give on page 14.

The Central Nervous System

The Central Nervous System (CNS) is made up of the brain and spinal cord.

A. The Brain

READ

Read the sections of your textbook entitled, "The Brain and Its Parts" (pp. 141 to 154).

The brain began in the developing embryo sac as an expansion of the neural tube. The neural tube develops first into the spinal cord and then the anterior end expands into the forebrain, midbrain and hindbrain. The hollow central canal in the spinal cord continues forward as the ventricles of the brain. These spaces are filled with **cerebrospinal fluid** which cushions and protects the central nervous system. **Meninges** and the bony **skeleton** also serve as protective structures. The arrangement of grey and white matter is the same in the brain and spinal cord, with the grey matter on the inside and the white matter on the outside (the cerebrum and cerebellum are important exceptions to this rule).

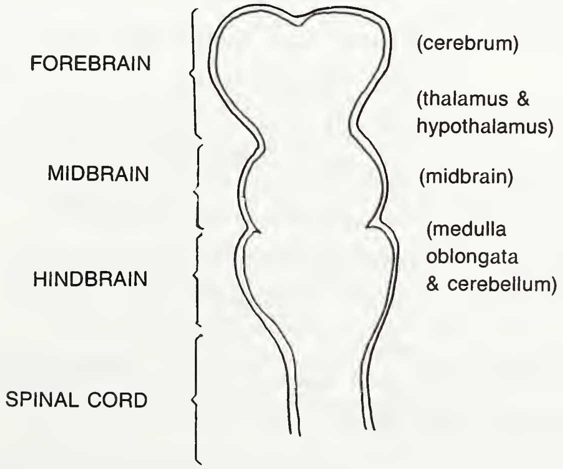


Figure 5: Embryonic development of the Central Nervous System.

Refer to your textbook for the structure and function of the following major parts of the brain.

Hindbrain (medulla oblongata and cerebellum)

Pons

Midbrain

Thalamus and Hypothalamus

Cerebrum (4 major areas)

Note also those areas which pertain to the **motor cortex, sensory cortex,** speech, association and memory.

Note the function of **commisural** fibres, **association** fibres and **projection** fibres in the brain.

B. Cranial Nerves

There are 12 pairs of cranial nerves in human beings. For the most part, the cranial nerves innervate the important receptors of the head and the muscles of the eyeball, face and throat. They are involved in eye movements, facial expressions, chewing and speaking. An important exception is the vagus nerve (cranial nerve X). This descends into the trunk to innervate the heart, lungs and digestive tract as part of the Autonomic Nervous System.

READ

Read the lesson notes and the pages in the textbook that deal with the brain and then complete Exercise 4.

Exercise 4

Fill in the blanks.

1. The brain is divided into three parts: the ________________, the ________________ and the ________________.
2. The ________________ is most highly developed in the human species and is present as two ________________ hemispheres.
3. Regulation of breathing and blood pressure are two functions of the ________________ ________________.
4. Destruction of the ________________ would mean that a person would lose balance and coordination.
5. The area of the brain between the medulla and the midbrain is known as the ________________.

6. An area of the brain essential for eye and ear reflexes is the ________________ .

7. The "master gland" of the body is the ________________ which hangs just below the ________________ .

8. The hypothalamus controls the ________________ nervous system, some special secretions,as well as some ________________ and emotional responses.

9. The ________________ forms a sensory relay station to the brain. It also affects consciousness, temperature and the degree of awareness of pain.

10. The ________________ cortex is folded into deep folds or ________________ and shallow folds or ________________ .

11. The ________________ ________________ crosses from one cerebral hemisphere to the other.

12. The four lobes of the cerebral hemisphere are the ________________ , ________________ , ________________ and ________________ .

13. Voluntary muscle control is a function of the ____________ cortex located in the ________________ lobe on either side of the ________________ fissure.

14. There is a ________________ correlation between the motor areas that we use the most and the proportion of the brain devoted to their control.

15. Sensory activities are governed by the ______________ lobe. However the ______________ lobe gathers sensory information for sight and the ______________ lobe governs hearing.

16. The left side of the cerebral cortex controls muscles on the ________________ side of the body due to the large number of nerve fibres that cross over in the ______________ ________________ .

17. Sorting and organizing sensory information takes place in the ________________ areas.

18. Musical and artistic ability appear to belong to the ________________ hemisphere.

19. Repeated and reinforced events may modify brain proteins or the synapses to produce __________ -term memory.

20. White ________________ fibres transmit impulses between the two halves of the brain.

21. There are ________________ pairs of cranial nerves. Most are associated with facial muscles of the ear and eye. Number ______ , the _____________, is the exception as it runs to the trunk.

22. Auditory stimuli are relayed to the brain via the _______________ nerve (VIII), while visual stimuli travel along the _____________ nerve (II). Chemical receptors in the nose transmit impulses to the brain via the ________________ nerve (I).

23. The brain is protected by the skull and _______________ . The three layers are called the _________ mater, _______ mater and _______________ .

24. The brain and spinal cord are buffered against injury by the ____________________ fluid.

Please check your work with the answers given on pages 15 and 16.

C. The Spinal Cord

READ

Read the section in your textbook on the Spinal Cord (pp. 154 to 158).

The following is a cross section of the spinal cord. The structures and functions are outlined as follows.

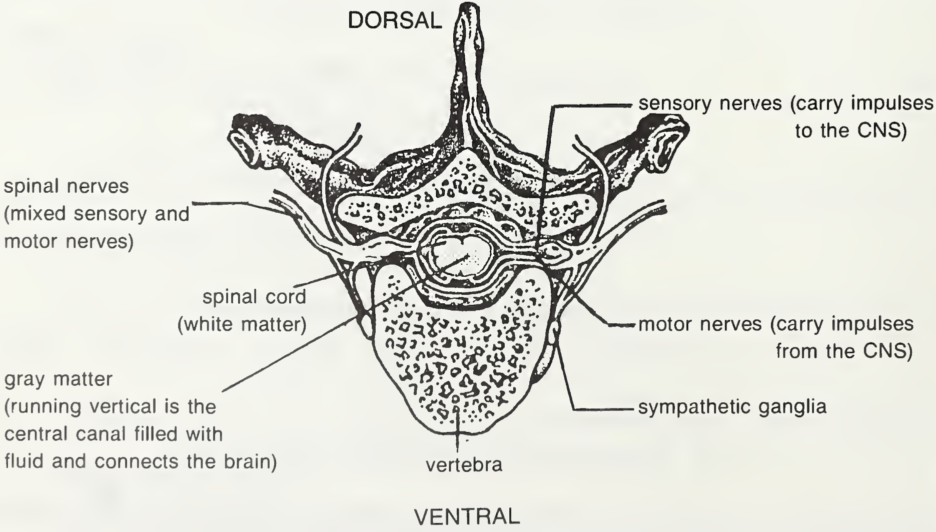

DORSAL
sensory nerves (carry impulses to the CNS)
spinal nerves (mixed sensory and motor nerves)
spinal cord (white matter)
motor nerves (carry impulses from the CNS)
gray matter (running vertical is the central canal filled with fluid and connects the brain)
sympathetic ganglia
vertebra
VENTRAL

Figure 6: Cross-section of a spinal cord

The two main functions of the spinal cord are to serve as a connection to the peripheral nervous system and to serve as a minor coordinating centre where reflex action can take place.

Sensory information is received along the dorsal roots of the spinal cord from the peripheral nerves and sent up special tracts to the brain. Motor information is transferred down tracts from the brain and travels out the ventral roots of the spinal cord. (You can feel the dorsal-most processes of your vertebrae by running your finger down your spine.)

Reflex Arc

Some actions such as pulling your hand away from a hot stove or having your knee jerk when the doctor taps it with a hammer do **not** have to be processed by the brain before action is taken. These "automatic" actions are due to reflex arcs located in your spinal cord. The five basic parts of a reflex arc include:

1. a receptor (to receive a stimulus)
2. a sensory neuron
3. an association neuron
4. a motor neuron
5. an affector - (e.g. muscle, to act upon the stimulus)

Following a reflex activity, information is sent to the brain for future reference. Some reflexes are learned. These learned or **conditioned reflexes** save us time. Examples include knowing where to find the brake on a car and knowing how to use your fingers on a typewriter.

Exercise 5

TRUE/FALSE. Circle the correct letter, **T** or **F**, to indicate whether the statement is True or False.

1. The spine is another word for the spinal cord. T F
2. Nerves that control the pelvis and legs originate in the lumbar region. T F
3. Nerve impulses are carried towards the CNS via the sensory nerves. T F
4. Motor nerves leave the spinal cord via the dorsal root of the spinal cord. T F
5. White matter of the spinal cord is made up of unmyelinated fibres. T F
6. The spinal cord is protected by three layers of meninges, cerebrospinal fluid and bone. T F
7. Information within a reflex arc must pass to the brain before action is taken. T F
8. The affector is the part of the reflex arc receiving the stimulus. T F
9. The association neuron occurs between the receptor and the spinal cord. T F
10. The motor neuron connects the affector to a neuron in the spinal cord. T F

11. Acquired or conditioned reflexes involve the cerebrum. T F

12. Paraplegics have lost the use of all four limbs. T F

Please check your work with the answers given on page 16.

The Autonomic Nervous System

READ

Read the section in your textbook on the Autonomic Nervous System (pp. 158 to 161).

This system consists of sensory and motor neurons positioned between the CNS and the internal organs. Its function is to detect changes in the internal environment and respond appropriately.

These actions are involuntary and involve two major types of neurons - preganglionic fibres (run to spinal cord) and postganglionic fibres (run to effectors). The following diagram locates these structures in relation to the CNS, the ganglion (collection of cell bodies) and the effectors.

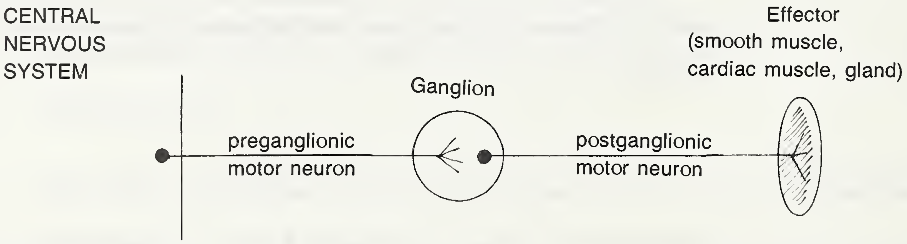


Figure 7: Structures of the Autonomic Nervous System.

The autonomic nervous system is subdivided into the sympathetic and parasympathetic nervous systems. These two may be separated from each other both physically and physiologically. In general, where the two systems innervate the same structure they have opposite effects and the activity of that structure depends upon the balance of impulses from the two systems.

The sympathetic nervous system has a short preganglionic neuron with the ganglia lying in two rows on either side of the spinal cord. This system gets us ready for "fight or flight" in an emergency situation. The postganglionic neuron is long and widely dispersed so the effect is less localized than the parasympathetic system.

The parasympathetic nervous system arises anteriorly with certain cranial nerves (especially X) and posteriorly with the sacral nerves. The postganglionic neuron is short and near the effector.

When you were a child, your parents probably told you not to run or swim right after a meal. They were probably right. By avoiding vigorous exercise you give your parasympathetic nervous system a chance to work. Give your body ''a break today'' by not exciting your sympathetic system.

The **adrenal medulla** is also innervated by the sympathetic nervous system. There are no postganglionic fibres arising from it, instead the adrenal gland secretes adrenalin directly into the bloodstream. The effects are similar to those of the rest of the sympathetic system, preparing the body for an emergency or stress - but the effects are more powerful and more long lasting.

Exercise 6

TRUE/FALSE. Indicate if the statements are True (T) or False (F) by circling the correct letter.

1. Maintenance of normal body function is the main function of the autonomic nervous system. T F
2. Postganglionic nerve fibres arise in the ganglia and pass to an effector. T F
3. Preganglionic fibres arise in the ganglia and pass to a receptor. T F
4. The autonomic nervous system is entirely independent of the CNS. T F
5. If you rescue a child from falling downstairs your sympathetic nervous systm will likely have taken over. T F

Please check your work with the answers give on page 16.

ANSWERS TO THE KEYED EXERCISES

Exercise 1, p. 2.

Fill in the blanks.

1. Nerve cell projections which conduct impulses towards the nerve cell body are called **dendrites**.
2. Nerve cell projections conducting impulses away from the nerve cell body are called **axons.**
3. Axons may be insulated with a fatty **myelin** sheath, produced by **Schwann** cells.
4. Some axons may be repaired due to the presence of a **neurilemma.**
5. ''White matter'' consists mostly of **myelinated axon fibres.**
6. ''Grey matter'' consists mainly of **unmyelinated fibres** and **cell bodies**.

Exercise 2, p. 4.

True or False Questions.

1. **True.**
2. **True.**
3. **False.** Potassium ions (K^+) are located primarily on the inside of an axon.
4. **True.**
5. **True.**
6. **True.**
7. **False.** Repolarization of a membrane is reestablished by the active transport of sodium ions (Na^+) to the outside.
8. **False.** During an action potential, sodium ions rush into the axon, creating a negative charge on the outside of the membrane. This lasts for only about 1/1000 of a second, till the membrane is repolarized.
9. **True.**
10. **False.** The refractory period refers to the brief period between action potentials during which the nerve cannot be stimulated.

Exercise 3, pp. 6 and 7.

Circle the correct answer.

1. The neurons of the nervous system (do/[✓ do not]) make physical contact.
2. Chemical transmitters are released from synaptic vesicles found in the ([✓ presynaptic]/postsynaptic) neuron.
3. Chemical transmitters like acetylcholine cause the ([✓ depolarization]/repolarization) of the postsynaptic membrane.
4. Action potentials are fired when ([✓ sodium ions]/potassium ions) enter the dendrites of the receiving neuron.
5. Sufficient depolarization is usually affected when (one/[✓ several]) synaptic knobs fire.
6. Acetylcholine must be destroyed by ([✓ cholinesterase]/noradrenalin) to prevent runaway firing of the postsynaptic neuron.
7. A nerve impulse is transmitted ([✓ one way]/both ways) across a synaptic gap.
8. Some synapses may prevent firing of a postsynaptic neuron and are called ([✓ inhibitory]/refractory) synapses.

Exercise 4, pp. 8 to 10.

Fill in the blanks.

1. The brain is divided into three parts: the **forebrain**, the **midbrain** and the **hindbrain.**

2. The **forebrain** is most highly developed in the human species and is present as two **cerebral** hemispheres.

3. Regulation of breathing and blood pressure are two functions of the **medulla oblongata**.

4. Destruction of the **cerebellum** would mean that a person would lose balance and coordination.

5. The area of the brain between the medulla and the midbrain is known as the **pons**.

6. An area of the brain essential for eye and ear reflexes is the **midbrain**.

7. The "master gland" of the body is the **pituitary** which hangs just below the **hypothalamus**.

8. The hypothalamus controls the **autonomic** nervous system, some special secretions, as well as some **behavioral** and emotional responses.

9. The **thalamus** forms a sensory relay station to the brain. It also affects consciousness, temperature and the degree of awareness of pain.

10. The **cerebral** cortex is folded into deep folds or **fissures** and shallow folds or **sulci**.

11. The **corpus callosum** crosses from one cerebral hemisphere to the other.

12. The four lobes of the cerebral hemisphere are the **frontal, temporal, parietal** and **occipital**.

13. Voluntary muscle control is a function of the **motor** cortex located in the **frontal** lobe on either side of the **central** fissure.

14. There is a **direct** correlation between the motor areas that we use the most and the proportion of the brain devoted to their control.

15. Sensory activities are governed from by the **parietal** lobe. However the **occipital** lobe gathers sensory information for sight and the **temporal** lobe governs hearing.

16. The **left** side of the cerebral cortex controls muscles on the **right** side of the body due to the large number of nerve fibres that cross over in the **medulla oblongata.**

17. Sorting and organizing sensory information takes place in the **association** areas.

18. Musical and artistic ability appear to belong to the **right** hemisphere.

19. Repeated and reinforced events may modify brain proteins or the synapses to produce **long**-term memory.

20. White **commissural** fibres transmit impulses between the two halves of the brain.

21. There are **12** pair of cranial nerves. Most are associated with facial muscles of the ear and eye. Number **X** , the **vagus,** is the exception as it runs to the trunk.

22. Auditory stimuli are relayed to the brain via the **acoustic** nerve (VIII), while visual stimuli travel along the **optic** nerve (II). Chemical receptors in the nose transmit impulses to the brain via the **olfactory** nerve (I).

23. The brain is protected by the skull and **meninges.** The three layers are called the **dura** mater, **pia** mater and **arachnoid**.

24. The brain and spinal cord are buffered against injury by the **cerebrospinal** fluid.

Exercise 5, pp. 11 and 12.

True or False Questions

1. **False.** The spinal cord is part of the brain stem which extends through each of the bones of the spine.
2. **True.**
3. **True.**
4. **False.** Motor nerves leave the spinal cord via the **ventral root** of the spinal cord.
5. **False.** White matter of the spinal cord is made up of **myelinated** fibres.
6. **True.**
7. **False.** If the stimulus is strong enough the brain is bypassed and action is taken immediately via the reflex arc.
8. **False.** The **receptor** is the part of the reflex arc receiving the stimulus.
9. **False.** The **sensory** neuron occurs between the receptor and the spinal cord.
10. **True.**
11. **True.**
12. **False.** Paraplegics have lost the use of their lower limbs.

Exercise 6, p. 13.

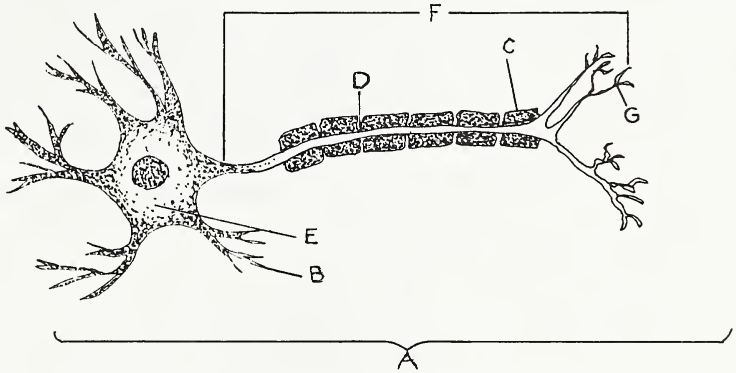
True or False Questions.

1. **True.**
2. **True.**
3. **False.** Preganglionic fibres extend from within the CNS to synapses in the ganglia.
4. **False.** The autonomic nervous system is controlled largely by the hypothalamus, which is part of the central nervous system, so it is not an independent system.
5. **True.**

EXERCISES TO BE SENT IN FOR CORRECTION

Exercise 1 - The Nervous System

1. Match the statements below with the correct part of the nerve by placing the letter from the diagram in the blank beside each statement. Each letter MAY BE used more than once.



_______ cells which form the myelin sheath

_______ gaps which may boost the impulse along the fibre

_______ designed to carry nerve impulses from one point to another

_______ contains the nucleus of the neuron

_______ structure for the pick-up of nerve impulses

_______ structure which carries impulses away from the cell body

_______ short, highly branched nerve processes

G structure which releases the chemical, acetylcholine

_______ cholinesterase destroys acetylcholine, preventing the stimulation of which structure?

Exercise 2 - Nerve Impulses

Part One: Multiple Choice

Select the best response to each statement and place the appropriate letter in the space to the left.

________ 1. When an impulse moves through a nerve it travels from the

(a) cell body to the dendrite to the axon.
(b) dendrite to the cell body to the axon.
(c) axon to the cell body to the dendrite.
(d) dendrite to the axon to the cell body.

________ 2. The neuron that conducts nervous impulses from a receptor to the CNS is called

(a) motor.
(b) coordinating.
(c) sensory.
(d) association.

________ 3. Nerve impulses travel in one direction because of the

(a) unequal distribution of ions.
(b) location of chemical transmitter receptor sites.
(c) length of the axon.
(d) local currents set up at the nodes of Ranvier.

________ 4. A nerve impulse will travel faster if it is

(a) initiated by a stronger stimulus than normal.
(b) travelling along a myelinated axon.
(c) given a long refractory period.
(d) part of a reflex arc.

________ 5. Inability to hear might indicate a non-functional

(a) vagus nerve.
(b) acoustic nerve.
(c) oculomotor nerve.
(d) glossopharyngeal nerve.

________ 6. The ventral root of a typical peripheral nerve entering the spinal cord contains

(a) both motor and sensory pathways.
(b) sensory fibres.
(c) fibres carrying impulses to muscles.
(d) none of the above

________ 7. "Gray matter" consists of

(a) myelinated sensory neurons.
(b) unmyelinated axons.
(c) nerve cell bodies.
(d) both (b) and (c)
(e) (a), (b) and (c)

________ 8. Acetylcholine is a chemical transmitter which

(a) depolarizes the receiving neuron membrane.
(b) closes the Na^+ gates on the receiving neuron.
(c) repolarizes a neuron.
(d) makes a membrane more permeable to K^+.

________ 9. A lack of cholinesterase would cause nerves to

(a) fire repeatedly causing spasms and tremors.
(b) become fatigued.
(c) fail to reach threshold levels.
(d) become repolarized.

________ 10. A stimulus of 70 millivolts (mV) applied to a dendrite end causes an impulse to travel along the neuron. A stimulus of 50 mV produces a similar action. This demonstrates that

(a) 50 mV is the threshold level
(b) above a threshold value, the neural response is constant
(c) depolarization is not dependent upon the strength of the stimulus
(d) the greater the voltage difference, the stronger the neural response

Part Two: Short Answer

1. (a) Describe the kinds of ions present and their distribution on either side of a "resting" neuron.

____

____

____

(b) What is the difference in electrical potential across the membrane of a resting neuron?

____

____

____

2. (a) Describe the change in the distribution of ions as the action potential of a nerve impulse passes a point on the axon membrane.

(b) What is the change in electrical potential as a nerve impulse passes a point on the axon membrane?

3. What is the refractory period?

Exercise 3 - The Central Nervous System

1. Assume that the medulla oblongata had motor tracts cut on the left hand side so these tracts no longer conducted impulses. What would be the effect on muscle coordination on the left hand side of the body? Explain your answer.

2. Offer an explanation why the hand would have a larger portion of the motor cortex devoted to it than would the foot.

____

____

____

3. Fill in the name of the cranial nerve and indicate which sense would be lost if it were destroyed.

Numbers	Names	Sense
I		
II		
VIII		
IX		

4. Give three functions of cerebrospinal fluid.

(a) ______________________________

(b) ______________________________

(c) ______________________________

5. The meninges protect the Central Nervous System. The __________ __________ is closest to the skull. The __________ __________ covers the brain itself and the __________ is in between.

Exercise 4 - The Brain

1. Match the statements in column I with the items given in column II. Write the letter of the item described in the blank beside each statement. Each item in column II **may be** used more than once.

Column I

______ responsible for the relay of eye and ear reflexes

______ is often called the master gland

______ sensory relay centre on way to cerebrum

______ the surface is composed of grey matter

______ deals with motor coordination and muscle tone

______ activates breathing and stimulates the diaphragm

______ protective layers of the brain

______ is divided into four lobes, each marked by fissures

______ internal bridge between the two cerebral hemispheres

______ areas which are probably responsible for mental activities such as creativity, memory, etc

______ coordinating centre for activities of internal organs

______ contains tracts between hindbrain and forebrain

Column II

A. pons
B. thalamus
C. medulla oblongata
D. cerebellum
E. cerebrum
F. corpus callosum
G. frontal lobes
H. hypothalamus
I. midbrain
J. pituitary
K. meninges
L. cerebrospinal fluid

Exercise 5 - Spinal Cord

1. What function do reflexes generally serve?

____

____

____

2. What part of the nervous system does an acquired or conditioned reflex involve that a spinal reflex does not involve?

____

3. List the three neurons in a three-neuron reflex arc.

   (a) _______________

   (b) _______________

   (c) _______________

4. Define the following terms.

   (a) Receptor - _______________

   ____

   (b) Affector - _______________

   ____

5. If the spinal cord is severed, a loss of sensation and voluntary muscle control will occur below that area. Explain why.

____

____

____

Exercise 6 - The Autonomic Nervous System

Select the best response to each statement and place the appropriate letter in the space to the left.

______ 1. The nerve fibres that accelerate the heartbeat belong to the same system as those that

(a) constrict the pupil.
(b) increase intestinal peristalsis.
(c) accommodate the lens for near vision.
(d) promote the release of glucose from the liver.

2. Describe the changes which take place in your autonomic nervous system when a child unexpectedly runs in front of a car in which you are riding.

____

____

____

____

____

____

____

____

END OF LESSON 11

LESSON RECORD FORM

3230 Biology 30
Revised 03/89

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Date Lesson Submitted ______________________

Time Spent on Lesson ______________________

(If label is missing
or incorrect)

File Number ______________________

Lesson Number __________

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Assigned
Teacher: __________

Lesson Grading: __________

Additional Grading
E/R/P Code: __________

Mark: __________

Graded by: __________

Assignment Code: __________

Date Lesson Received:

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Student's Questions and Comments

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ALBERTA CORRESPONDENCE SCHOOL

MAILING INSTRUCTIONS FOR CORRESPONDENCE LESSONS

1. BEFORE MAILING YOUR LESSONS, PLEASE SEE THAT:

(1) All pages are numbered and in order, and no paper clips or staples are used.
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2. POSTAGE REGULATIONS

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Send all letters in a separate envelope.

3. POSTAGE RATES

First Class

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Try to mail each lesson as soon as it has been completed.

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OBJECTIVES

When you have completed Lesson 12 you should be able to:

1. **Define** a sensory receptor and **explain** its reaction to a strong stimulus.
2. **Label** the structures of the eye.
3. **Outline** the functions of the various structures of the eye.
4. **Understand** how vision is accomplished.
5. **Understand** several eye problems in terms of structure and how they can be corrected.
6. **List** the two major functions of the ear and the structures which are the site of these functions.
7. **Label** the major structures of the ear.
8. **Discuss** how hearing occurs.
9. **Account** for some common hearing disorders.
10. **Outline** the importance of the ear in relation to balance.
11. **Understand** the ways in which we taste and smell.

SENSORY RECEPTORS

Introduction

In order for the central nervous system to make the correct responses to changes in the environment, it must be supplied with accurate information about these changes. This information is supplied by the **sensory receptors**.

Sensory receptors convert the information about the external environment into nerve impulses and then relay it to the central nervous system. There are a variety of sensory receptors to respond to the many kinds of **stimuli** - light, sound, heat, cold, pressure, touch, chemicals, gravity, acceleration and pain. Each individual receptor, however, is only capable of responding to one type of stimulus. Mechanoreceptors, for example, only respond to pressure not heat or cold. In this lesson we shall deal with the receptors of pressure and temperature (skin), light (eye), sound (ear), equilibrium (ear) and chemicals (nose and taste buds).

Sensory receptors have several characteristics in common:

1. They must all include the peripheral ending of a sensory neuron.
2. Stimulation of the receptor results in an initiating generator potential which then stimulates action potentials along the neuron.
3. The stronger the stimulus, the greater the frequency of action potentials produced. The brain can then determine the strength of the stimulus.
4. Most sensory receptors are able to adapt quickly to a stimulus. Constant exposure to a certain stimulus leads to an increased insensitivity of the sensory receptors to that same stimulus. This is to prevent the brain from being bombarded by insignificant information - such as the touch and pressure of our clothing.
5. Stimulation of a receptor results in only one type of sensation; e.g. if you poke your finger in your eye, the sensation experienced is seeing flashes of light.
6. The cerebral cortex can localize which receptors have been stimulated because the body is represented spatially in the sensory cortex (front part of the parietal lobe) just as motor areas were represented on the frontal lobe (refer to Figure 1 of this lesson).
7. Some receptors have large areas of the brain devoted to their interpretation; such as, the visual area of the occipital lobe and the auditory cortex of the temporal lobe.

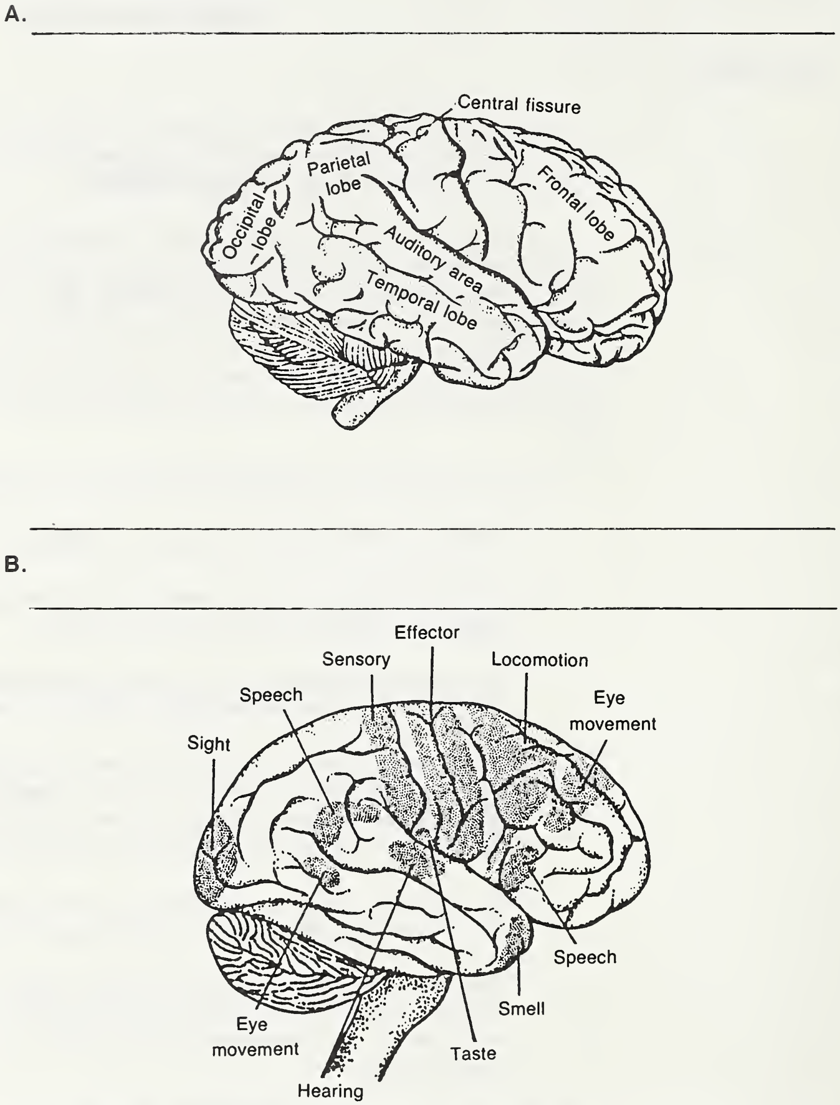


Figure 1: A. Lobes of the cerebral hemisphere. B. Functional areas of the cerebral hemisphere.

Skin Receptors - Pressure and Temperature

READ

Read the sections of your text dealing with the sense receptors in the skin (pp. 66-68).

The skin has receptors for touch or pressure, heat, cold and pain. Some of these receptors seem to be **naked nerve endings** of sensory nerves. Other sensory nerve endings are enclosed by a capsule consisting of alternating layers of cells and extracellular fluid. An example of this type of nerve ending is shown in the diagram of a mechanoreceptor known as a pacinian corpuscle (see figure 2).

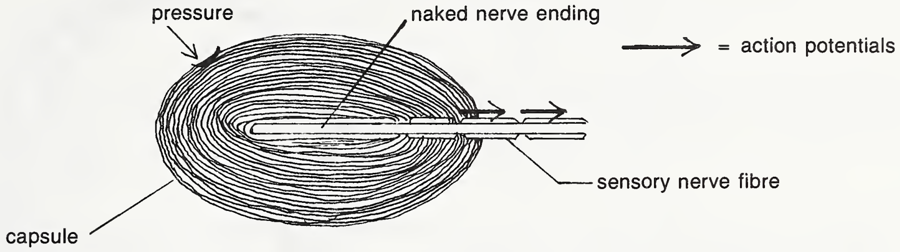


Figure 2: A pacinian corpuscle: an example of a pressure receptor.

A. Pressure Receptors

Touch or pressure receptors are not evenly distributed in the surface of the skin, nor are they equally sensitive. Skin on the fingertips and around the mouth and tongue are the most sensitive areas while the chest, abdomen and back are the least sensitive areas. The sensory neurons are farther apart in the least sensitive areas of the skin.

B. Temperature Receptors

There are about ten times more cold receptors than heat receptors. Our temperature receptors cannot tell absolute temperature but only give information about temperature changes in the region immediately surrounding them. Some areas of the body are less sensitive to temperature differences than others. For example, we are able to drink coffee at a temperature that is unbearable to our fingers because the membrane lining our mouth is relatively insensitive to heat.

The Eyes - Light Receptors

READ

Read pages 176 to 189 of your textbook.

Structure of the Eye

The optics of an eye are much like that of a camera: with an opening to allow light in, a lens system to bring the light into focus and a sensitive surface upon which an image can be formed. The eye, like all sensory receptors, generates nerve impulses and sends them along sensory neurons to the brain for interpretation.

Consult your textbook to learn more about the following: how the eye is protected by the skull, eyebrows and eyelashes, conjunctiva and tears formed in the lacrimal glands. Then use the following notes and your textbook to learn the structures and functions of the human eye.

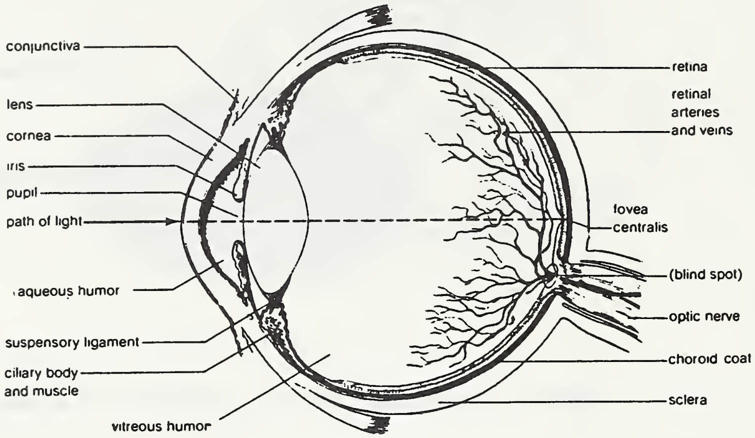


Figure 3: Human Eye

Following are the structures of the human eye and their functions:

sclera - tough, white **outer layer**.

cornea - transparent portion of sclera which admits light into the eye interior and bends it into the lens.

choroid layer - **middle layer** of the eye, pigmented with melanin and supplied with blood vessels. Its function is stopping stray light rays within the eye.

iris - **pigmented** portion of the choroid coat. The opening in it is the **pupil**. The iris controls the amount of light entering the eye, improving its ability in forming images and depth perception.

retina - **inner layer** of the eye. This is the most delicate layer and contains the actual light receptors - the **rods** and **cones**. From the retina all nerve cells lead to the optic nerve.

- **rods** - contain a light absorbing substance rhodopsin made of opsin and retinal. When light is absorbed by rhodopsin the retinal is split off and the rod is partially bleached.
- **cones** - abundant in the region of retina called the fovea centralis and operate in bright light enabling the human eye to distinguish color.

lens - has the ability to **change shape to shift focus** at different distances. This is accomplished through suspensory ligaments which contract and flatten, allowing for shape changes in the lens.

aqueous humor - space between the lens and cornea filled with a **watery** substance keeping the lens moist and protecting the eyeball from physical shock.

vitreous humor - **transparent** substance which keeps the eyeball firm and prevents its collapse, also protects the retina and nerve endings.

blind spot - contains no rods or cones on the **optic nerve** and is insensitive to light.

Function of the Photoreceptors

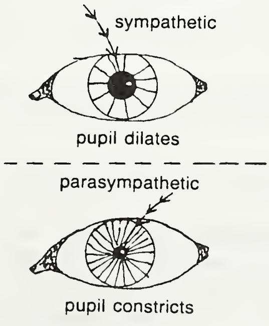
The actual photoreceptors of the eye are the **rods** and **cones** located in the retina. Light passes through several layers of cells before reaching these receptor cells. Rods and cones synapse indirectly with sensory neurons leading to the optic nerve.

Rods are sensitive to dim light but the images they form are coarse and poorly defined. This is because rods function in groups - a number of rods sharing a single nerve circuit to the brain. A single rod can initiate an impulse to the brain but the brain has no way of knowing which rod in the cluster was simulated.

Since they are sensitive to dim light, rods are important in **night vision**. The visual pigment in rods (**rhodopsin**) requires Vitamin A for its production. (Carrots are an excellent source of Vitamin A!) A difficiency of Vitamin A is usually associated with nightblindness, the inability to see in the dark.

Colour is detected by the cones located in the retina. There are three basic kinds of cones and each type of cone is able to detect one of the three primary colours - red, green and blue. Combinations of these colours enable us to see the wide variety of colours in the world around us. Cones are concentrated near the central part of the retina in an area called the **fovea centralis.** This area of the retina is used for finely detailed vision because of the high concentration of cones. The absence or weakness of one of the cone types, usually red or green, leads to the sex-linked trait known as **colour-blindness**.

Reflexes of the Eye

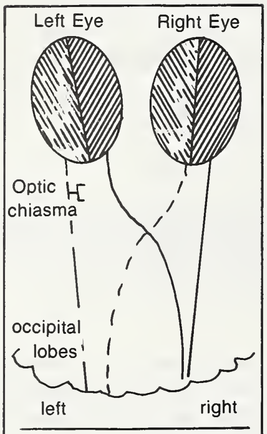


Innvervation of the Iris

The autonomic nervous system governs the two sets of nerves that control the muscles of the iris. When the **sympathetic** system discharges, the radial muscles of the iris contract and the **pupil** becomes **dilated** for dim light and distance vision. The **parasympathetic** system stimulates the circular muscles of the iris to contract, **constricting** the **pupil** for bright light and near vision (accommodation reflex).

Binocular Vision

VISUAL FIELDS



Right visual fields are interpreted in the right occipital lobe. (The left visual fields are interpreted in the left side of the brain.)

In order to make accurate estimates of distances and depth we require two eyes producing two images. Our type of vision, which requires similar images from each eye, is known as binocular vision. Our eyes are about 6.4 cm apart, from centre to centre. This results in slightly different images being sent to the brain because each eye sees things from a slightly different angle. The brain uses the images from the eyes to put together an image that has thickness and shape. This image then allows the brain to judge distance and depth.

After the rods and cones have been stimulated by light, the sensory impulses are sent to the brain along the optic nerves. The sensory pathway passes through the thalamus and then to the occipital lobes of the cerebral cortex. The right half of the visual area of each eye is interpreted by the right occipital lobe. This means that the ''nose-side'' tracts of the optic nerves cross over to the opposite lobes at the base of the brain in a region known as the optic chiasma.

Disorders of the Eye

Light rays entering the eye are normally focused on the retina to produce a clear upside-down image. If the eyeball is misshapen then the image may fall in front of the retina (**nearsightedness or myopia**) or behind the eyeball (**farsightedness or hypermetropia**). Wearing corrective lenses helps correct these conditions by focusing the image on the retina.

Astigmatism, which causes a distorted image on the retina, is caused by uneven curvature of the cornea or lens.

Exercise 1

Indicate if the following statements are True (T) or False (F) by circling the correct letter.

T F 1. All sensory receptors contain part of a sensory neuron.

T F 2. More of the sensory cortex is devoted to the mouth and lips than the back and thighs.

T F 3. There are more heat receptors than cold receptors.

T F 4. A pinch could be distinguished from a pat by the brain because the action potentials would be more frequent from the pinch.

T F 5. The extrinsic eye muscles are arranged in antagonistic pairs.

T F 6. The conjunctiva shade the eyes from the sun.

T F 7. Lacrimal secretions wash away dust and lubricate the eye.

T F 8. The sclera contains many blood vessels and pigmented granules.

T F 9. The retina contains 2 types of light-sensitive receptors.

T F 10. Stimulation of iris muscles by the sympathetic system causes the pupil to constrict.

T F 11. The pupil contains pigmented cells.

T F 12. The retinal cells sensitive to dim light are the rods.

T F 13. The optic nerve leaves the eye at the blind spot.

T F 14. Most of the rods are found at the fovea centralis.

T F 15. Pupils accommodate to objects close up by constricting.

T F 16. Shifting the active reception of light from cones to rods is called the light reflex.

T F 17. Our depth perception is made possible by having binocular vision.

T F 18. The field of vision from the nose-side of the right eye is interpreted by the right occipital cortex.

T F 19. In nearsightedness, the eyeball is too short, so the retinal image is incorrectly placed.

Please check your work with the answers given on pages 10 and 11.

The Ear - Sound and Balance

READ

Read pages 195 to 204 in your textbook.

The ear has two functions: hearing and balance. Hearing receptors are contained within the cochlea and balance receptors are contained within the utricle, saccule and semicircular canals. All of these receptor cells are in the inner ear with nerves leading from them to the cerebral cortex.

The ear is divided into three parts: the outer ear, the middle ear and the inner ear (see figure 4).

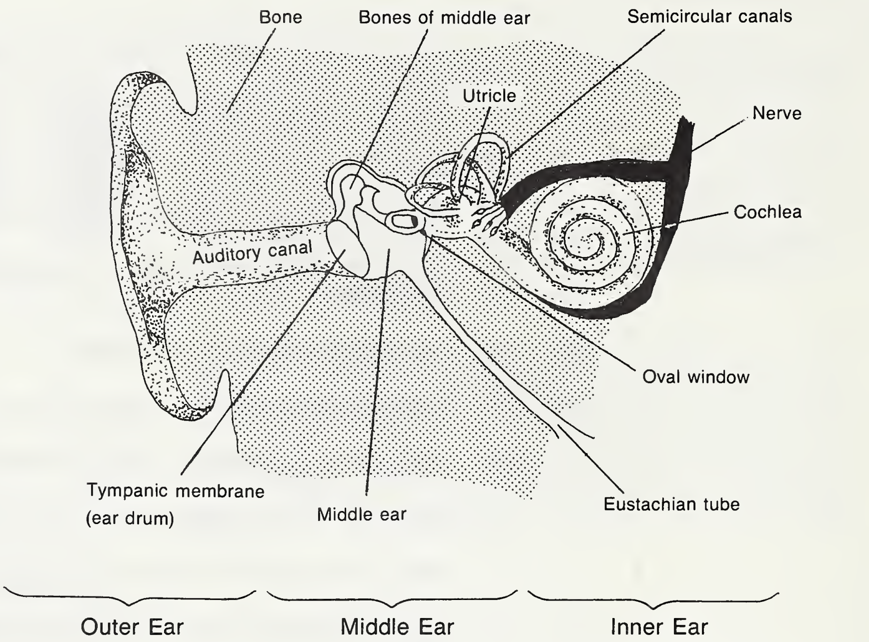
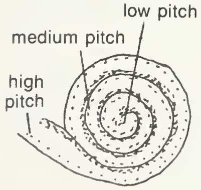


Figure 4: Anatomy of the External, Middle and Inner Ear

The outer ear aids in concentrating sound waves which pass down the auditory canal, strike the tympanic membrane (eardrum) and cause it to vibrate. Three tiny linked bones (the ossicles) transmit these vibrations across the middle ear.

The middle ear, filled with air, is responsible for equalization of pressure on both sides of the tympanic membrane. This is aided by the **eustachian tube** which provides a connection to outside air.

Both the outer and middle ear contain air whereas the inner ear contains a fluid. For **hearing**, sound wave vibrations are transmitted to the cochlea via the **oval window**. The cochlea is coiled like a snail's shell, contained within a labyrinth of bone. The cochlea is divided into three parts, each filled with fluid. The sound receptors are contained within the cochlear duct and are surrounded by endolymph. The cochlear duct is surrounded by perilymph, contained in the scala vestibuli and the scala tympani of the cochlea. Sound waves pass through the fluid to the sound receptors of the organ of Corti. Excess sound-wave pressure is relieved at the **round window**, just below the oval window of the cochlea.



Pitch Reception in the Cochlea

The sensitive "hair" cells which receive the sound vibrations are located in the organ of Corti between two membranes - the basilar and tectorial membranes. Vibrations of the fluid cause vibrations of the basilar membrane, bending the hair cells. These cells emit electrical impulses, initiating action potentials which travel to the cerebral cortex (temporal lobes) via the auditory nerve.

READ

Read the section of your text dealing with hearing disorders (pp. 201 and 202).

Balance

The **utricle, saccule** and **semicircular canals** are found in the inner ear and are responsible for balance. These structures are filled with fluid and have patches of sensory hairs which are connected to the brain. The utricle and saccule respond to any changes in the head with respect to gravity. Small particles of calcium carbonate (otoliths) move in response to gravity. These particles bend the sensory hairs, triggering impulses which let the brain know the position of the head.

The semicircular canals lie in three planes at right angles to each other. The sensory hairs within these canals are stimulated by the movement of the endolymph. Movement of the body, to any position, will result in impulses being sent to the brain. The brain interprets these impulses and sends out motor impulses to maintain balance by stimulating the appropriate skeletal muscles.

Exercise 2

Indicate whether the statement is True (T) or False (F) by circling the correct letter.

T F 1. The three ossicles of the middle ear amplify sound energy while transferring it to the inner ear.

T F 2. The membrane separating the middle and inner ear is called the oval window.

T F 3. The round window relieves pressure from vibrations set up in the cochlea by the oval window.

T F 4. "Cupping" the outer ear does not help us hear better.

T F 5. Conduction deafness is due to damage to the auditory nerve conducting impulses to the brain.

T F 6. Low notes cause longer hairs in the organ of Corti to vibrate.

T F 7. The hearing range for human beings is from 16 Hz to 20,000 Hz.

T F 8. Sounds with an intensity of 50 dB could cause hearing loss.

T F 9. Calcium carbonate particles, floating within the endolymph of the organ of Corti, trigger hair cells, indicating the new position of the head.

T F 10. Turning motions are detected by the semicircular canals.

Please check your work with the answers given on page 11.

Taste Buds and Nose - Chemoreceptors

Read pages 204 to 206 in your textbook.

Receptors to chemical stimuli in the environment are the **taste buds** and the **olfactory epithelia** in human beings. Four kinds of taste buds give rise to four basic tastes; salty, sweet, bitter and sour. However, a combination of taste plus smell, temperature and touch receptors give rise to a variety of new sensations.

Smell or odor receptor cells located in the olfactory epithelia give rise to the sensation of smell. Our olfactory nerves soon become accustomed to smells (become fatigued) and do not fire as often.

In summary, our reponse to stimuli depends on specific receptors. All of these receptors must have a lower threshold for a specific stimulus, be connected to a sensory neuron and be capable of initiating nerve impulses. When a sensation does occur and we are conscious of that sensation in the brain, the brain assigns meaning to the impulses that are received.

ANSWERS TO THE KEYED EXERCISES

Exercise 1, pp. 6 and 7

True or False Questions

1. **True**
2. **True**
3. **False.** There are more **cold** receptors than **heat** receptors, because cold is a greater threat to our maintenance of a standard body temperature.
4. **True**
5. **True**
6. **False.** The conjunctiva seals off the eye to prevent bacteria and other foreign matter from entering the body.
7. **True**
8. **False.** The sclera is a tough outer layer which helps to maintain the shape of the eye.
9. **True**
10. **False.** The iris muscles contract when stimulated by the sympathetic system causing the pupil to **dilate**.

11. **False**. The pupil is simply the opening in the iris.
12. **True.**
13. **True.**
14. **False.** There are **no rods** in the fovea centralis - only cones.
15. **True**
16. **False.** The light reflex is well known as the change in the size of the pupil in accordance with the light intensity.
17. **True**
18. **False.** The field of vision from the nose-side of the right eye is interpreted by the **left** occipital cortex.
19. **False.** In nearsightedness, the eyeball is **too long**, so the retinal image is incorrectly placed.

Exercise 2, p. 9.

True or False Questions

1. **True.**
2. **True.**
3. **True.**
4. **False.** "Cupping" the outer ear does help us hear better because this extends the effective size of the pinna and increases the amount of sound energy entering the ear.
5. **False. Nerve deafness** is due to damage of the auditory nerve or the sensory cells conducting impulses to the brain.
6. **True.**
7. **True.**
8. **False.** Sounds with an intensity of 100 dB can be uncomfortable and higher intensities can be painful and lead to a long-term hearing loss.
9. **False.** The calcium carbonate particles which stimulate hair cells, indicating the position of the head, are found in the **utricle and saccule**.
10. **True.**

EXERCISES TO BE SUBMITTED FOR CORRECTION

Exercise 1 - Sensory Receptors

Part One: Circle the correct answer.

1. Sensory receptors are specialized in that each type responds to (one/many) type(s) of stimuli. The stronger the stimulus the (greater the number/higher the peak) of the action potentials produced. All receptors include the peripheral ending of a (sensory/motor) neuron.

2. Sensory information is represented spatially in the brain in a sensory area located in the (frontal/parietal) lobe. Some receptors have large areas of the cerebral cortex devoted to them, such as the (visual/auditory) area of the occipital lobe and the (visual/auditory) area of the temporal lobe.

Part Two: Short Answer

1. What receptors do pacinian corpuscles contain?

2. What evidence is there that heat receptors are not equally distributed over the body?

3. Why are we not constantly aware of the touch and pressure of our clothing?

Exercise 2 - The Eye and Vision

1. Use the following list of structured parts of the eye to indicate the pathway of light from the cornea to the retina. Use arrows (→) to show the path of light. List: aqueous humor, lens, retina, vitreous humor, cornea, pupil.

   cornea → ______________________________

   ____

   ____

   ____

2. What is the special advantage of having two eyes?

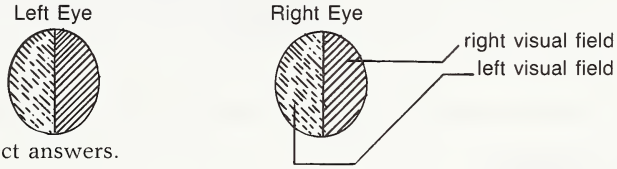
   ____

   ____

   ____

   ____

Use the following diagram to help you answer the next question.



3. Circle the correct answers.

   If the right occipital cortex was damaged, vision would be lost from the (right/left) visual field of the right eye and the (right/left) visual field of the left eye.

4. Why do concave lenses help correct myopia (nearsightedness)?

   ____

   ____

5. How does Vitamin A function to prevent "night blindness"?

   ____

   ____

6. Place the letter of the best answer beside the statement to which it refers.

______ Enables eye to shift focus to objects at different distances.

______ Stops the reflection of stray light rays.

______ Condition where image focuses before the retina and is out of focus when light strikes the retina.

______ Contains light receptors.

______ Light rays not focusing due to irregularities in the lens or cornea.

______ Protects eye from too much light.

______ Keeps lens moist and protects eyeball from shock.

______ Responsible for shape of lens.

______ Condition where light rays are not focused before they strike the retina.

______ Keeps the eyeball firm and prevents its collapse.

(a) Nearsightedness
(b) Lens
(c) Aqueous Humor
(d) Cones
(e) Suspensory Ligaments
(f) Vitreous Humor
(g) Pupil
(h) Farsightedness
(i) Rods
(j) Retina
(k) Astigmatism
(l) Optic Nerve
(m) Choroid
(n) Eyelids
(o) Iris

Exercise 3 - The Ear

1. What are the functions of the bones of the middle ear?

2. Explain briefly how stimulation of the hair cells of the Organ of Corti causes the sensation of hearing.

3. What handicaps would result from

   (a) clogged eustachian tube?

   ____

   (b) damage to the semicircular canals?

   ____

   (c) scar tissue on the tympanic membrane?

   ____

Exercise 4 - Chemoreceptors

1. How are the receptors of taste and the olfactory epithelia related?

   ____

   ____

2. What is meant by ''olfactory fatigue''?

   ____

   ____

3. If you had to take a bitter pill, which area of the tongue would you avoid putting it on?

   ____

4. Why can we not taste dry food?

   ____

Please submit pages 12 to 15 for correction.

END OF LESSON 12

LESSON RECORD FORM

3230 Biology 30
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Time Spent on Lesson ______

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Additional Grading
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OBJECTIVES

When you have completed Lesson 13 you should be able to:

1. **Explain** the major function of the endocrine system.
2. **Compare** the endocrine and nervous systems as to general structure and function.
3. **Locate** the positions of the various glands comprising the endocrine system in the body.
4. **List** the major hormones produced by the various glands of the endocrine system.
5. **Give** the functions of the major hormones in the body.
6. **Differentiate** between the endocrine and exocrine systems.
7. **Understand** the effects of the various hormones produced on the body.
8. **Assess** the homeostatic mechanisms at work between insulin and glucagon to maintain blood sugar levels.
9. **Explain** the feedback mechanisms between the various glands of the endocrine system.
10. **Outline** some of the implications resulting from deficiencies or excesses of certain hormones.

THE ENDOCRINE SYSTEM

Introduction

The two major control systems of the body are the endocrine system and the nervous system. Both systems help us react to changes in our internal and external environments and maintain homeostasis. The nervous system is highly organized, whereas the endocrine system is composed of scattered glands with no anatomical connection. In general, the endocrine system is more diffuse, less rapid and more prolonged in its effect than the nervous system.

The pituitary gland is the "master gland", controlling the endocrine system while the brain controls the nervous system. It has now been shown, however, that the two systems are coordinated not only physiologically but also anatomically in the hypothalamus.

READ

Read the section of your textbook entitled "The Endocrine System," (pp. 396 to 397).

Structure of Endocrine Glands

Endocrine glands secrete hormones directly into the bloodstream. These secretions do not pass through ducts as do secretions from the exocrine glands (see Figure 1). Some glands, like the pancreas, have both an exocrine and an endocrine function.

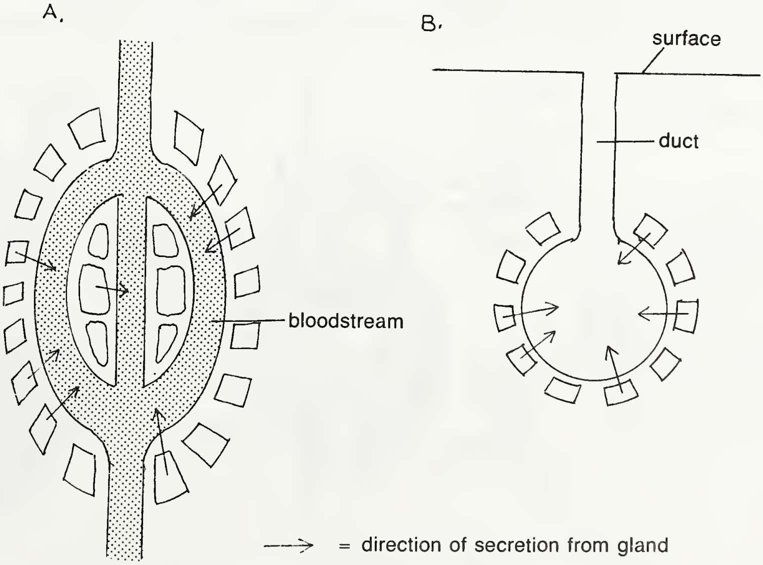


Figure 1: Endocrine gland (A) and Exocrine gland (B)

Characteristics of Endocrine Glands

Secretions from endocrine glands affect all the important aspects of life -- growth, physical and mental development, maintenance and reproduction. The glands do not usually start new reactions, but rather modify some aspect of the metabolism that is already taking place. They may speed up or slow down the action of a particular enzyme or change the membrane permeability for a particular molecule.

Since hormones circulate in the blood they come in contact with nearly every cell. The hormones will act with only certain **target cells** which have **receptor molecules** in or on them.

The Organs of the Endocrine System

Locate the eight major endocrine glands found on Figure 17.1 of your text. Each gland will now be discussed in some detail.

The Thyroid Gland

READ

Read the section of your textbook entitled "The Thyroid Gland" (pp. 398 to 400).

Locate the thyroid gland from the description given in the textbook and the information given in Figure 2.

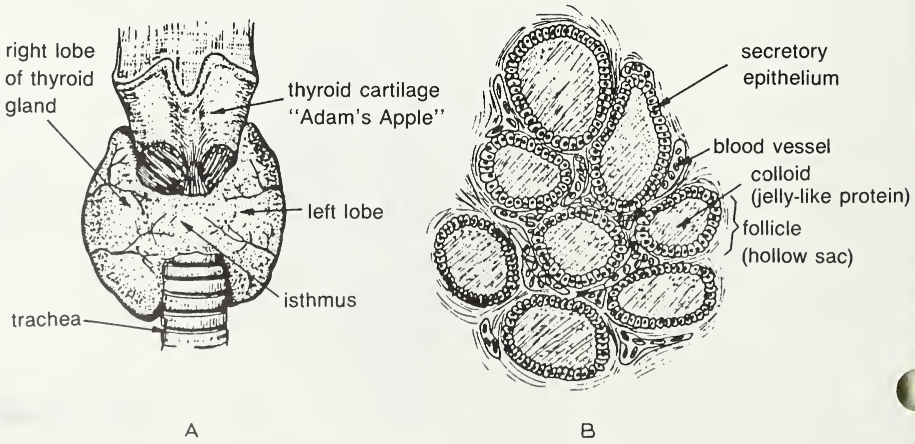

right lobe of thyroid gland
thyroid cartilage "Adam's Apple"
left lobe
isthmus
trachea
A
secretory epithelium
blood vessel
colloid (jelly-like protein)
follicle (hollow sac)
B

Figure 2: A. Thyroid gland. B. Cross section of thyroid follicles.

A. Thyroxin

The hollow sacs (follicles) of the thyroid gland contain the hormone **thyroxin** or the raw materials (**tyrosine and iodine**) to make it. Thyroxin is used to regulate the rate of body metabolism. One of the tests to see how well the thyroid is functioning is the speed with which the gland can concentrate a small amount of radioactive iodine. The other major hormone produced by the thyroid is **calcitonin**.

The three main effects of thyroxin are:

1. used to regulate the rate of body metabolism.
2. promotion of growth and development.
3. development of the nervous system.

"hypo" - Gr. - less than
"hyper" - Gr. - more than

Thyroid disorders may result from either too little thyroid hormone being produced (hypothyroidism) or too much (hyperthyroidism). A severely hypothyroid infant develops into a **cretin**. A hypothyroid adult suffers a slow down of all functions, fatigue and mental confusion in a condition known as **myxedema**. A **hyperthyroid** person releases large amounts of energy that are not used efficiently.

Regulation of thyroxin secretion is by a feedback mechanism between the amount of thyroxin in the blood and thyroid stimulating hormone (TSH) produced in the pituitary gland. A high level of thyroxin inhibits the secretion of TSH. If insufficient thyroxin is being produced, however, such as when there is a very low amount of iodine in the diet, blood thyroxin levels are low and TSH will continue to be produced. Over time the thyroid gland enlarges but thyroxin levels do not increase. The thyroid bulges in the neck causing a condition known as **goiter**. (See Figure 3)

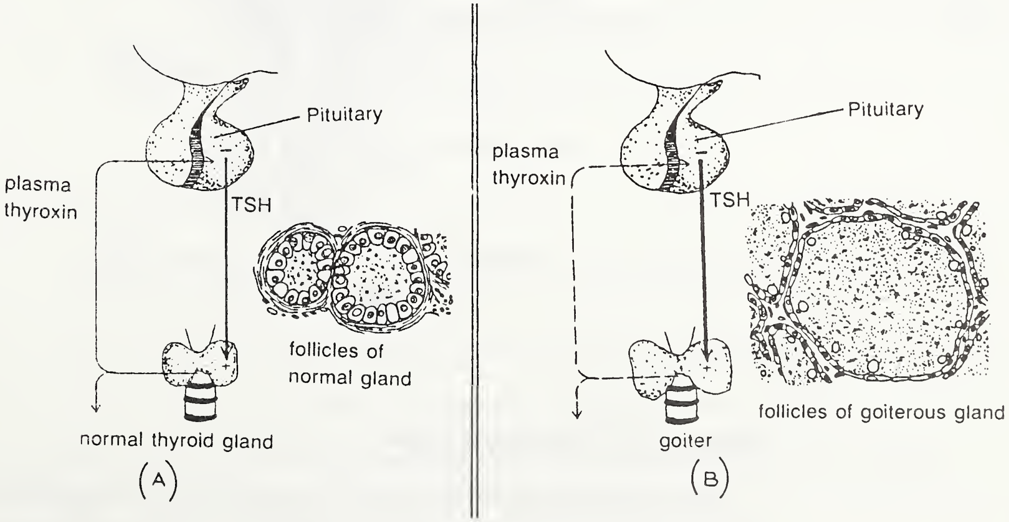


Figure 3: Feedback control of thyroxin production. A. Normal Thyroid Gland. B. Goiter.

B. Calcitonin

Calcitonin (thyrocalcitonin) is released when blood levels of calcium are high. Calcitonin promotes the storage of calcium and phosphate in the bone and helps maintain homeostasis of these mineral ions. The actions of calcitonin are aided by parathormone. The role of parathormone will be discussed with the parathyroid glands in the next section.

Parathyroid Glands

READ

Read the section of your textbook entitled "Parathyroid Glands" (pages 400 to 401).

Locate the parathyroid glands from the description in your textbook and the information given in Figure 4.

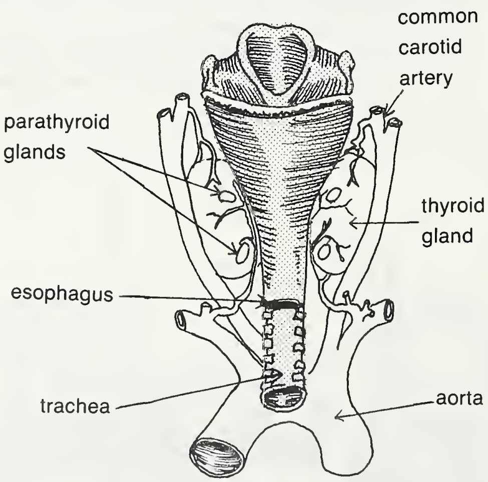


Figure 4: The Parathyroid Glands

Parathormone (PTH) regulates calcium metabolism and is essential for life. An adequate level of calcium in the blood must be maintained for the normal functioning of nerve and muscle cells. A deficiency of parathormone production (**hypoparathyroidism**) may lead to irregular twitches and spasms of muscle cells (tetany) and excessive irritability of the nervous system causing convulsions.

PTH raises the level of blood calcium by increasing the release of calcium from bone, reabsorbing calcium from the kidney and, with Vitamin D, absorbing calcium from the intestines. An excess of parathormone (**hyperparathyroidism**) may lead to brittle bones or deposits of calcium in soft tissues.

The regulation of parathormone is by a simple feedback mechanism between blood calcium levels and the parathyroid glands. Calcitonin, produced by the thyroid glands, also acts to protect the body from a sudden rise in plasma calcium which would otherwise be slowly taken care of by the feedback mechanism.

Exercise 1

Part One: Fill-in-the-blanks

1. The thyroid gland is found bridging the __________ __________. The two major hormones produced are __________ and __________ . Thyroxin promotes __________ metabolism, __________ , and development of the __________ system. Secretion of thyroxin is governed by a feedback mechanism between __________ produced in the pituitary and the thyroid glands.

2. Parathyroid glands are located in the __________ glands and they are usually __________ in number. Their chief secretion is __________ which regulates ______________________________ .

Part Two: TRUE or FALSE

Indicate whether the following statements are True or False by circling the correct letter - (T) or (F).

T F 1. Lack of thyroxin in the adult results in cretinism.

T F 2. Myxedema is the result of excessive secretion of thyroxin.

T F 3. In positive feedback the receptor keeps giving the same response.

T F 4. Goiter is the result of too little iodine in the diet.

T F 5. TSH stimulates the enlargement of the thyroid in goiter as a result of an attempt to make more thyroxin.

T F 6. Too much parathormone results in tetany.

T F 7. The homeostasis of calcium is determined by parathormone only.

Please check your work with the answers given on page 13.

The Pancreas

READ

Read the section of your textbook entitled "The Pancreas" (pp. 401 to 403).

Locate the pancreas in your body by using the notes given in your textbook. The long, thin pancreas lies in a loop of the small intestine beneath the stomach. It has both an **exocrine** and an **endocrine** function. The exocrine ducts secrete digestive enzymes into the duodenum. The 1 to 2% of tissue remaining (called the Islets of Langerhans) has an endocrine function producing **insulin** and **glucagon** to regulate blood glucose levels.

Insulin is a small protein which functions to **lower** blood glucose levels by increasing the metabolism and storage of glucose. Glucose is stored as glycogen in the liver. Fatty acids and amino acids are also stored as fats and proteins. Insulin works by increasing the permeability of the cell membranes to these substances.

A. Insulin Deficiency: Diabetes Mellitus

If the amount of insulin decreases or is absent altogether, the resulting chain of events will cause diabetes mellitus, which may result in coma and death.

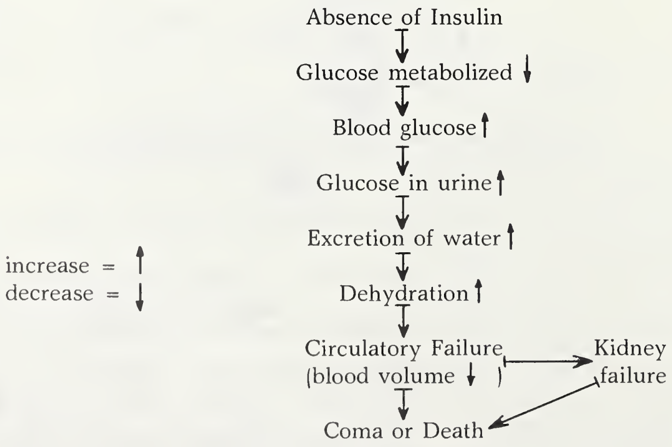


Figure 5: Chain of Events Possible with Insulin Deficiency

These symptoms may be controlled by injecting insulin and by maintaining a carefully controlled diet.

B. Excess Insulin (Hyperinsulinism)

Hyperinsulinism usually occurs as a result of an accidental overdose of insulin in a diabetic. The result is a drastic lowering of the blood glucose level. This is particularly serious since glucose is the main energy source for the brain. If the excess of insulin is great enough, the nervous system may become hyperexcitable leading to convulsions and death.

C. Glucagon

In general, glucagon has all the opposite effects of insulin. It **increases** the level of blood glucose. It stimulates the breakdown of glycogen to glucose. The stored glucagon is released when there is a low concentration of glucose in the blood.

Exercise 2

Indicate whether the following statements are True or False by circling the correct letter - (T) or (F).

T F 1. The digestive enzymes produced by the pancreas are emptied into the small intestine.

T F 2. The gland cells producing insulin and glucagon do not lead to a duct.

T F 3. Too little insulin may result in excess blood glucose.

T F 4. Too much insulin may result in glucose in the urine.

T F 5. Dehydration is a symptom of severe diabetes.

T F 6. Glucagon is the storage form of glucose in the liver.

T F 7. The kidney is the organ most affected by hyperinsulinism.

T F 8. Insulin promotes the storage of fats and proteins as well as glucose.

T F 9. Glycogen increases the amount of glucose in the blood.

T F 10. Eating a chocolate bar could help alleviate the symptoms of hyperinsulism.

Please check your work with the answers given on page 13.

Adrenal Glands

READ

Read the section of your textbook entitled "Adrenal Glands" (pages 403 to 406).

Locate the adrenal glands in the body with the help of your textbook. There are two major parts of the adrenal glands; the adrenal cortex and the adrenal medulla. (See Figure 6).

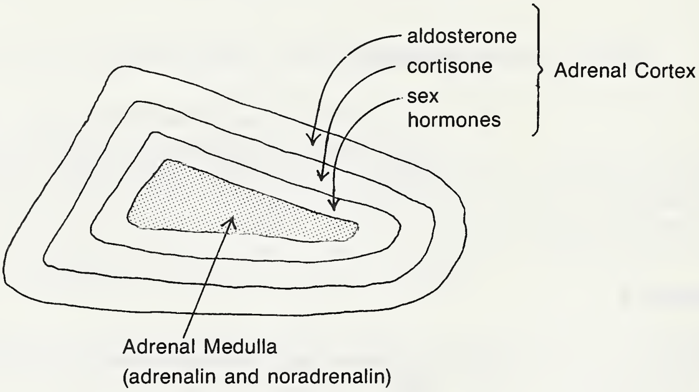


Figure 6: The Adrenal Gland

A. The Adrenal Medulla

The adrenal medulla serves both as an endocrine gland and as part of the sympathetic nervous system. The secretion of adrenalin (epinephrine) duplicates and augments the effects of the sympathetic nervous system during "fight or flight" situations. To help yourself remember all the effects our body systems go through under high stress, ask yourself what each system (muscular, circulatory, respiratory, etc.) would have to do in that situation. e.g. **Muscular System** - your muscles need to be ready for quick action so they are supplied with glucose and oxygen. More glucose is released from storage in the liver. Respiratory rates are increased and bronchial muscles relaxed so more oxygen is available.

B. The Adrenal Cortex

Thomas Addison in 1855 was one of the first people to describe the effects of a degenerated adrenal cortex. The deficiency is now known as Addison's disease and it has a large number of physiological and biochemical symptoms including:

(1) excessive loss of sodium in the urine

(2) low blood sugar

(3) low blood volume and blood pressure

(4) loss of weight related to a loss of appetite, vomiting and diarrhea

(5) an inability to withstand heat, cold or any kind of stress

(6) death due to kidney or circulatory collapse.

Addison's disease was not properly understood until the twentieth century when three different types of hormones were shown to be produced by the adrenal cortex.

Aldosterone - a mineralocorticoid which increases reabsorption of sodium and water by kidney tubules. In the total absence of aldosterone, the body would lose large amounts of sodium and water (diabetes insipidus).

Cortosal (commercially known as **cortisone**) a glucocorticoid which promotes the manufacture of glucose and increases the storage of glycogen in the liver in the form of glycogen. Body protein is broken down and converted into sugar to increase the blood glucose level. This is a valuable response during starvation when body protein must be sacrificed to maintain blood glucose levels for the functioning of the brain. It is not clearly understood, however, how this action helps us cope with emotional and other stresses. Excess secretion of this hormone may weaken the body.

Sex hormones - a group of sex hormones known as androgens are produced by the adrenal cortex but their effect is weak compared with those produced by ovaries and testes. Excessive production may cause precocious development of accessory reproductive structures in the male and masculinization in girls and women.

Control of adrenal cortical hormones is under the influence of Adrenocorticotrophic Hormone (ACTH) from the anterior pituitary gland by a feedback mechanism. The nervous system has further control over this gland, which is essential for life, by ACTH-releasing factors being released from the hypothalamus.

Exercise 3

Part One: Fill-in-the-blanks

The two parts of an adrenal gland are the adrenal ______________ and the adrenal ______________ . The central ______________ is stimulated by the ______________ system to produce ______________ and ______________ for "fight or flight" responses. The outer ______________ produces ______________ which are stimulated by ACTH produced in the ______________ gland.

Part Two: True or False

Indicate whether the following statements are True or False by circling the correct letter - (T) or (F).

T F 1. Blood glucose levels increase in the presence of adrenalin.

T F 2. Blood pressure increases in the presence of high levels of aldosterone.

T F 3. The pupil of the eye constricts if we are frightened.

T F 4. The rate of blood coagulation increases during an emergency.

T F 5. If excess salt is lost from the kidneys so is water.

T F 6. Cortisone maintains kidney water balance.

T F 7. Cortisone increases blood sugar levels.

T F 8. Excess cortisone may weaken the body by converting protein to sugar.

T F 9. Ovaries and testes are the only organs producing sex hormones.

T F 10. We can live without our adrenal medulla.

Please check your work with the answers given on page 14.

The Thymus Gland

READ

Read the section of your textbook entitled "The Thymus Gland" (page 406).

Locate the thymus gland in your body from the description given in your textbook. The exact role of the thymus gland remains controversial although it is closely related to the lymphocyte and antibody production of the immune system.

The Gonads: The Ovaries and Testes

READ

Read the section of your textbook entitled "The Gonads" (pages 406 and 407).

Locate the ovaries and testes in the body by using the diagram in your textbook. Know the general function of the male hormone (**testosterone**) and the female hormones (**estrogen and progesterone**) and how they are stimulated to be produced. More detail will be given on the role of these hormones in the Lessons on the reproductive system.

The Pituitary Gland

READ

Read the section of your textbook entitled "The Pituitary Gland" (pages 407 to 412).

Locate the pituitary gland from the description given in your textbook.

The pituitary gland has a dual nature with the **anterior pituitary** secreting most of the hormones and the **posterior pituitary** making a direct neural connection with the hypothalamus.

A. Anterior Pituitary

You should become familiar with the functions of the major hormones produced by the anterior pituitary.

1. Growth and Metabolism Hormones

(a) Growth Hormone - note that undersecretion of this hormone may produce dwarfism.

(b) Thyroid Stimulating Hormone (TSH)

2. The Adrenal Hormones

(a) Adrenocorticotrophic Hormone (ACTH)

(b) Melanocyte Stimulating Hormone (MSH)

3. The Gonadotropins

(a) Follicle Stimulating Hormone (FSH)

female

(b) Luteinizing (or Lutenizing) Hormone (LH)

male (c) Interstitial Cell Stimulating Hormone (ICSH)

4. Others

(a) Prolactin - controls and sustains milk production

B. Posterior Pituitary

The posterior pituitary stores two hormones formed in the hypothalamus of the brain and releases them upon stimulation.

1. **Antidiuretic Hormone (ADH)** - which controls the reabsorption of water by the kidney tubules (also known as vasopressin).
2. **Oxytocin** - which aids both in the contraction of the uterus during birth and the "let-down" of milk from the mammary glands.

When disease strikes both the anterior and posterior pituitary glands a short, sexually immature, mentally retarded Frohlich's **dwarf** may result. Oversecretion of the pituitary may result in **gigantism** if it affects a child or **acromegaly** in an adult.

The endocrine and the nervous system work together closely to maintain homeostasis in the body.

Exercise 4

Part One: Fill-in-the-blanks

The _______________ pituitary is glandular while the _______________ pituitary has a direct connection with the hypothalamus. Second action hormones (hormones stimulating others to produce) include ___________ and _______________.

Part Two: TRUE or FALSE

Indicate whether the following statements are True or False by circling the correct letter - (T) or (F).

T F 1. A deficiency of growth hormone and TSH in infants may lead to dwarfism.

T F 2. An oversecretion of growth hormone in adulthood leads to gigantism.

T F 3. ACTH stimulates the adrenal medulla.

T F 4. An ovary is stimulated to develop by estrogen.

T F 5. LH causes the ovum to be released and the corpus luteum to develop.

T F 6. The production of testosterone is stimulated by ICSH.

T F 7. A lack of ADH would cause swelling due to retention of water by the kidneys.

T F 8. Oxytocin is essential for uterine contraction during childbirth.

T F 9. Skin pigmentation is due to luteinizing hormone.

T F 10. Homeostasis is controlled by both the endocrine and nervous systems.

Please check your work with the answers given on page 14.

ANSWERS TO KEYED EXERCISES

Exercise 1, p. 5

Part One: Fill in the blanks

1. The thyroid gland is found bridging the **Adam's apple**. The two major hormones produced are **thyroxin** and **calcitonin**. Thyroxin promotes **oxidative** metabolism, **growth**, and development of the **nervous** system. Secretion of thyroxin is governed by a feedback mechanism between **TSH** produced in the pituitary and the thyroid gland.

2. Parathyroid glands are located in the **thyroid** glands and they are usually **4** in number. Their chief secretion is **parathormone** which regulates **calcium levels in the blood**.

Part Two: True or False

1. **False -** Lack of thyroxin in an **infant** results in cretinism.
2. **False -** Myxedema is the result of **under**secretion of thyroxin.
3. **True**
4. **True**
5. **True**
6. **False -** Too **little** parathormone results in tetany.
7. **False** - Parathormone and Calcitonin **both** determine calcium levels in the blood.

Exercise 2, p.

1. **True**
2. **True**
3. **True**
4. **False -** Too **little** insulin leads to glucose in the urine.
5. **True**
6. **False - Glycogen** is the storage form of glucose in the liver.
7. **False - The brain** is most affected since glucose is its main energy source.
8. **True**
9. **False - Glucagon** increases the amount of glucose in the blood.
10. **True**

Exercise 3, pp. 9 - 10.

Part One: Fill-in-the-blanks

The two parts of an adrenal gland are the adrenal **cortex** and the adrenal **medulla**. The central **medulla** is stimulated by the **nervous** system to produce **adrenalin** and **noradrenalin** for "fight or flight" responses. The outer **cortex** produces **corticoids** which are stimulated by ACTH produced in the **pituitary** gland.

Part Two: TRUE or FALSE

1. **True**
2. **True -** Aldosterone stimulates water reabsorption thus increasing blood pressure.
3. **False -** The pupil **enlarges** if we are frightened.
4. **True**
5. **True**
6. **False - Aldosterone** maintains kidney water balance.
7. **True**
8. **True**
9. **False -** The **adrenal cortex** also produces some sex hormones.
10. **True**

Exercise 4, pp. 12 - 13

Part One: Fill-in-the-blanks

The **anterior** pituitary is glandular while the **posterior** pituitary has a direct connection with the hypothalamus. Second action hormones (hormones stimulating others to produce) include **TSH** and **ACTH**.

Part Two: TRUE or FALSE

1. **True**
2. **False -** An oversecretion of growth hormone in adulthood leads to **acromegaly**.
3. **False -** ACTH stimulates the **adrenal cortex**.
4. **False -** An ovary is stimulated to develop by **FSH.**
5. **True**
6. **True**
7. **False -** A lack of ADH causes a **large amount of watery urine.**
8. **True**
9. **False - Melanocyte stimulating hormone** is responsible for skin colour.
10. **True**

EXERCISES TO BE SENT IN FOR CORRECTION

Exercise 1 - General Characteristics of the Endocrine System

1. Define homeostasis.

2. (a) Explain how the levels of TSH and thyroxin in the circulatory system affect each other.

   (b) Explain how a goiter develops.

3. Briefly describe how the pancreas can act as both an endocrine and exocrine gland.

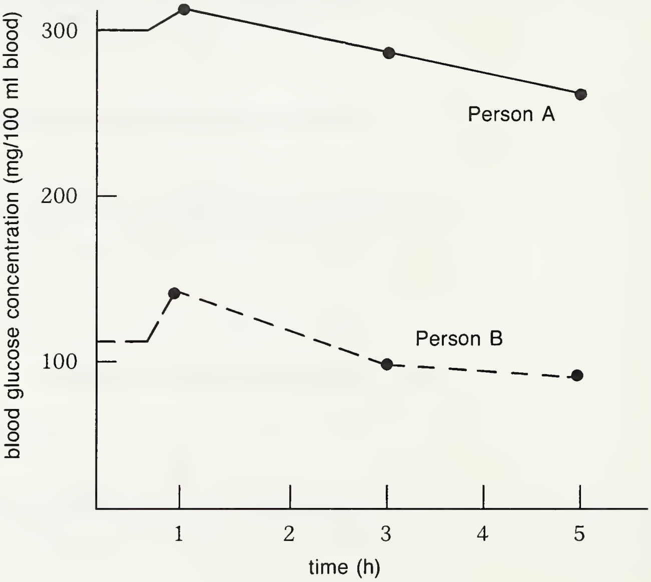
Exercise 2 - Blood Sugar Control

1. (a) Under normal circumstances, the blood sugar level ranges from 80 to 120 mg/100 ml blood. After a meal, the level may rise to about 130 mg/100 ml blood. This stimulates the secretion of insulin.

Blood samples were taken from two people (A and B)

- 1 h after a meal.
- 3 h after a meal.
- 5 h after a meal.

The blood was tested for glucose concentration and the results obtained are plotted on the graph below.



From the above graph which person would be suspected of being a diabetic? Give your reasons.

(b) What effect would an injection of insulin have on the diabetic?

(c) If the diabetic took too much insulin what would be some of his symptoms?

____

____

____

____

2. Summarize the effects of glucagon and adrenalin on blood glucose levels.

Glucagon - ________________________________

____

Adrenalin - ________________________________

____

Exercise 3 - Multiple Choice

For each of the following questions, choose the best answer and write the appropriate letter in the blank provided.

______ 1. If the production of ADH (vasopressin) is increased, the chief end result will be increased

(a) water reabsorption by the tubules.
(b) excretion of water via the urine.
(c) sodium reabsorption by the tubules.
(d) potassium reabsorption by the distal tubules.

______ 2. The pituitary is a major endocrine gland because it

(a) is located at the base of the brain and receives impulses directly from the cerebrum.
(b) is the largest gland in the body.
(c) produces hormones that influence the activities of the other glands in the body.
(d) directly controls every other gland and organ in the body.

______ 3. The formation of freckles is due to the secretion of MSH. The organ responsible is the

(a) parathyroid gland.
(b) thymus.
(c) kidney.
(d) anterior pituitary gland.

______ 4. Growth hormone is responsible for

(a) increasing the rate of protein synthesis in cells.
(b) promoting growth.
(c) all of the above.
(d) none of the above.

______ 5. Oversecretion of growth hormone during infancy results in a condition known as

(a) acromegaly.
(b) cretinism.
(c) Frolich's dwarfism.
(d) gigantism.

______ 6. The target organ for the hormone oxytocin is the

(a) kidney.
(b) uterus.
(c) bladder.
(d) pancreas.

______ 7. The body increases the blood concentration of calcium by secreting

(a) parathormone.
(b) calcitonin.
(c) cortisol.
(d) thyroxin.

______ 8. Hyperglycemia, increased urine production, and thirst are all symptoms of:

(a) hyperthyroidism.
(b) diabetes mellitus.
(c) hypothyroidism.
(d) hyperinsulinism.

______ 9. If a person is diagnosed as having a high metabolic rate, which endocrine gland is probably malfunctioning?

(a) parathyroids
(b) thymus
(c) posterior pituitary
(d) anterior pituitary

______ 10. Estrogen is secreted by cells of the

(a) posterior pituitary.
(b) anterior pituitary.
(c) ovary.
(d) uterus.

______ 11. Masculinization of a female is a result of the oversecretion of

(a) follicle stimulating hormone.
(b) posterior pituitary hormones.
(c) adrenal cortical hormone.
(d) leutenizing hormone.
(e) testosterone.

______ 12. Production of progesterone follows the secretion of

(a) posterior pituitary hormone.
(b) FSH.
(c) ICSH.
(d) LH.

______ 13. A disease characterized by low blood sugar, excessive loss of sodium and an inability to withstand stress would probably be due to a malfunctioning

(a) adrenal medulla.
(b) thyroid.
(c) pancreas.
(d) adrenal cortex.

______ 14. Regulation of Ca^{++} (calcium) levels in the bloodstream is the function of the

(a) adrenals.
(b) thyroid gland.
(c) parathyroid glands.
(d) (a) and (b)
(e) (a) and (c)
(f) (b) and (c)

______ 15. Before milk production is stimulated in the mammary glands and secretion continued in the lactating mother it requires the action of

(a) prolactin and oxytocin.
(b) prolactin and progesterone.
(c) estrogen and oxytocin.
(d) progesterone and estrogen.

______ 16. A tumor present in the cells of the Islets of Langerhans might result in the body's inability to

(a) lower blood glucose levels.
(b) regulate blood pressure.
(c) lower blood calcium levels.
(d) increase blood calcium levels.

______ 17. The loss of large volumes of watery urine (diabetes insipidus) follows the body's inability to retain Na^+ ions and Cl^- ions. The problem is probably due to the

(a) hyposecretion of ADH.
(b) hypersecretion of ADH.
(c) hyposecretion of aldosterone.
(d) hypersecretion of aldosterone.

______ 18. A goiter is due to the lack of which of the following minerals?

(a) calcium
(b) iodine
(c) sodium
(d) potassium

Exercise 4 - Adrenal Medulla

1. One sunny day while walking down a sidewalk you notice a child dart between parked cars. You dash to rescue the child from oncoming traffic. To prepare your body, adrenalin has been released from the adrenal medulla. Outline the effects of adrenalin on the following body systems and processes.

(a) Circulatory System -

____

____

____

(b) Respiratory System -

____

____

____

(c) Muscular System -

(d) Blood Glucose Levels -

(e) Eye pupil reflexes -

Please submit pages 15 to 21 for correction.

END OF LESSON 13

LESSON RECORD FORM

3230 Biology 30
Revised 03/89

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Date Lesson Submitted

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Time Spent on Lesson

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(If label is missing
or incorrect)

File Number

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Lesson Number __________

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Additional Grading E/R/P Code: __________

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ALBERTA CORRESPONDENCE SCHOOL

MAILING INSTRUCTIONS FOR CORRESPONDENCE LESSONS

1. BEFORE MAILING YOUR LESSONS, PLEASE SEE THAT:

(1) All pages are numbered and in order, and no paper clips or staples are used.
(2) All exercises are completed. If not, explain why.
(3) Your work has been re-read to ensure accuracy in spelling and lesson details.
(4) The Lesson Record Form is filled out and the correct lesson label is attached.
(5) This mailing sheet is placed on the lesson.

2. POSTAGE REGULATIONS

Do **not** enclose letters with lessons.

Send all letters in a separate envelope.

3. POSTAGE RATES

First Class

Take your lesson to the Post Office and have it weighed. Attach sufficient postage and a **green first-class sticker to the front of the envelope, and seal the envelope. Correspondence lessons will travel faster if first-class postage is used.**

Try to mail each lesson as soon as it has been completed.

When you register for correspondence courses, you are expected to send lessons for correction regularly. Avoid sending more than two or three lessons in one subject at the same time.

OBJECTIVES

At the end of Lesson 14 the student should be able to:

1. **Define** excretion.
2. **Explain** how the lungs, skin and digestive tract are also sites of the excretion of metabolic wastes.
3. **Label** a diagram of the kidney excretory system.
4. **Describe** the internal structures of a longitudinal section of a kidney.
5. **Give** the structures found in each part of the kidney a function.
6. **Define** nephron.
7. **Locate** the tubular structures of a nephron.
8. **Understand** how the blood supply of a nephron operates.
9. **Follow** the formation of urine from the glomerulus to the collecting duct.
10. **Understand** the role of the nephron in the maintenance of homeostasis as well as urine formation.
11. **Tell** by what process glomerular filtrate is made.
12. **List** the major molecules found in the blood before and after it leaves the glomerulus.
13. **Understand** the role active transport takes in the distribution of molecules in the proximal tubule.
14. **Discuss** the reabsorption of Na^+ in the proximal and distal tubules and the loop of Henle.
15. **Tell** the function of aldosterone in Na^+ reabsorption.
16. **Understand** the processes involved and location of water reabsorption along the nephron tubules.
17. **Discuss** Na^+ and water absorption in the Loop of Henle.
18. **Discuss** the role of ADH in water retention in the distal and collecting tubules.
19. **Trace** the pathway of urine from the collecting duct to the urethra.
20. **Understand** the two control mechanisms involved in micturation.
21. **Discuss briefly** the operation of an artificial kidney.

THE EXCRETORY SYSTEM

Introduction

Excretion is a term usually used narrowly to mean the elimination of urine from the kidneys. In fact, any process which rids the body of metabolic wastes is called excretion. To this end, the lungs, skin and colon are also organs of excretion.

Metabolic wastes are formed from the chemical activities of cells. These wastes include carbon dioxide, bile pigments, nitrogenous wastes, ions (Na^+, K^+, Ca^{++}, Cl^- and $PO_4^=$) and various other atoms and molecules. Most of the atoms and molecules can be reused but other substances must be eliminated or their accumulation will prove to be toxic.

Carbon dioxide is excreted by the lungs. The skin excretes a substance not unlike dilute urine with a combination of salts, urea and water. The liver excretes bile pigments from the breakdown of hemoglobin and these, along with certain metals, pass with the feces. The main role of the digestive system, however, is to rid the body of undigested food residue which has not been metabolized by the body. The most important metabolic wastes, the nitrogenous compounds, are eliminated through the kidneys. The three major nitrogenous compounds include **urea** from the breakdown of proteins, **uric acid** from nucleic acids and **creatine** from creatine phosphate found in muscles.

The second and perhaps more important function of the kidneys is their role in homeostasis. Normal biological processes depend upon the concentration of water and ions being held within narrow limits, regardless of large variations of intake and abnormal losses resulting from disease (hemorrhage, diarrhea, vomiting, etc.). The regulatory role of the kidneys is awesome and assures that body sodium is kept at the correct level no matter how much salt you eat and assures that you will eliminate excess water. The kidney also functions in acid-base balance.

Structure of the Kidney and Urinary System

READ

Read the section of your textbook entitled "The Organs of the Urinary System" (pages 378 to 391).

Locate the kidneys in your body by examining the diagrams in your textbook and Figure 1. Learn the names of all major structures.

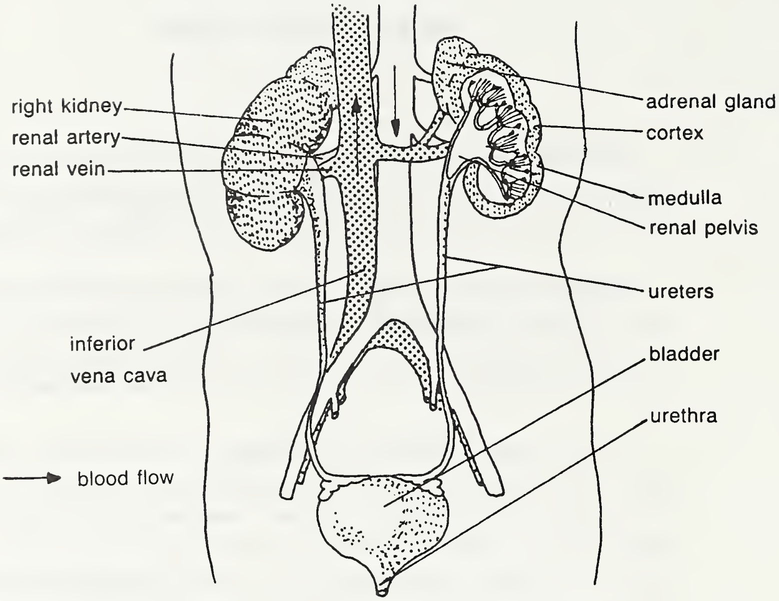


Figure 1: Location and Structure of the Kidneys

The two 9 cm kidneys lie on either side of the vertebral column in the back abdominal wall. In a longitudinal section of a kidney you can identify three sections: the outer **cortex**, the inner **medulla** and a **renal pelvis** which is the flared end of the ureters. The **ureters** lead to the **bladder** and **urethra**. The blood supply of the kidney is through a **renal artery** branching off the aorta. Blood leaves the kidney through the **renal vein** which empties into the inferior vena cava.

The Nephron

The basic unit of kidney function is the **nephron** and each kidney has about 1 million of them. These are the structures that actually form the urine. Each nephron is composed of two basic components:

1. a specialized tubule
2. a blood supply (the glomerulus)

The mechanisms by which kidneys perform their functions depend upon the relationship between these two components.

A. The Specialized Tubule

The nephron starts as a blind sac called the **Bowman's capsule** which surrounds the glomerulus in a cuplike manner. The Bowman's capsule leads to a highly coiled **proximal convoluted tubule**. These portions of the tubule are found in the cortex. The next part of the tubule, the **loop of Henle** dips into the medulla. The tubule becomes coiled again as the **distal convoluted tubule** and then runs straight as the **collecting tubule**. All of the collecting tubules empty into the **renal pelvis** which leads to the **ureter**. A single layer of epithelial cells lines the tubules for most of their length but the function of the cells varies in each portion of the tubular structure.

B. The Blood Supply (Glomerulus)

Blood enters the kidney through the **renal artery** which branches into smaller arterioles and finally the compact ball of capillaries in the glomerulus. Note the unusual arrangement of the blood vessels and the glomerulus. Blood enters the glomerulus via the **afferent arteriole** and leaves via the **efferent arteriole** rather than a venule. The efferent arteriole leads to a more complex group of capillaries that surround the nephron tubules to absorb various ions, food, and water as it passes. Blood finally passes out of these capillaries into the **renal vein**.

Exercise 1

Part One: TRUE or FALSE

Circle the correct letter (T or F) to indicate whether the statement is True or False.

T F 1. Excretion is the term reserved for the elimination of urine from the body.

T F 2. The skin excretes a substance like dilute urine.

T F 3. Carbon dioxide and alcohol may be excreted through the lungs.

T F 4. The more water you drink, the more urine will be excreted.

T F 5. Excess salt in your diet will result in more salt being retained by the body.

T F 6. The kidneys lie right next to the urinary bladder.

T F 7. The unit of structure of the kidney is called a neuron.

Part Two: Matching

Match the structures on the right to the description given on the left.

______ Outer edge of the kidney

______ Located in the renal medulla

______ Blood supply of the nephron

______ Tubular structure near Bowman's capsule

______ Tube leading from excretory system to the outside of the body

______ Tubular structure leading to the collecting duct

______ Urine is stored here

______ Blood vessel entering the glomerulus

______ Blood vessel leaving the glomerulus

______ Blood vessel leaving the kidney

A. Proximal convoluted tubule

B. Loop of Henle

C. Distal convoluted tubule

D. Bowman's capsule

E. Glomerulus

F. Ureter

G. Urethra

H. Bladder

I. Renal Medulla

J. Renal Cortex

K. Afferent arteriole

L. Efferent arteriole

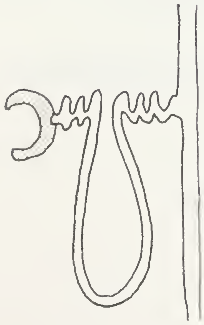
M. Renal artery

N. Renal vein

Please check your work with the answers given on pages 7 and 8.

Mechanism of Kidney Function - Urine Formation

A. Glomerular Filtration



As blood flows through the glomerulus about 1/5 of the plasma (not including red blood cells, platelets and plasma proteins) filters, under high blood pressure, into the **Bowman's capsule**. This is called the **glomerular filtrate**. The rest of the blood bypasses the nephron and re-enters the bloodstream. The filtrate is a solution of water, glucose, amino acids, urea and soluble salts. As it passes through the tubules, wastes like urea must be eliminated while many ions and glucose must be retained. The retention of selected molecules and ions is the job of tubular reabsorption. Of the approximate 100 mL of filtrate formed per minute, 99 mL of this is reabsorbed with a net rate of 1 mL of urine formed per minute. In some forms of kidney disease, plasma proteins may be present in the filtrate and will be present in the urine.

B. Tubular Reabsorption

The selective reabsorption in the tubules takes place through a combination of diffusion, osmosis and active transport. The composition of the blood is monitored and the wastes are removed. Remember that there is no urine in blood. Urine is blood plasma with all the useful substances removed and is found in the collecting tubule. Refer now to your textbook, Figure 2 and the following notes for the specific reabsorption of materials across the nephron.

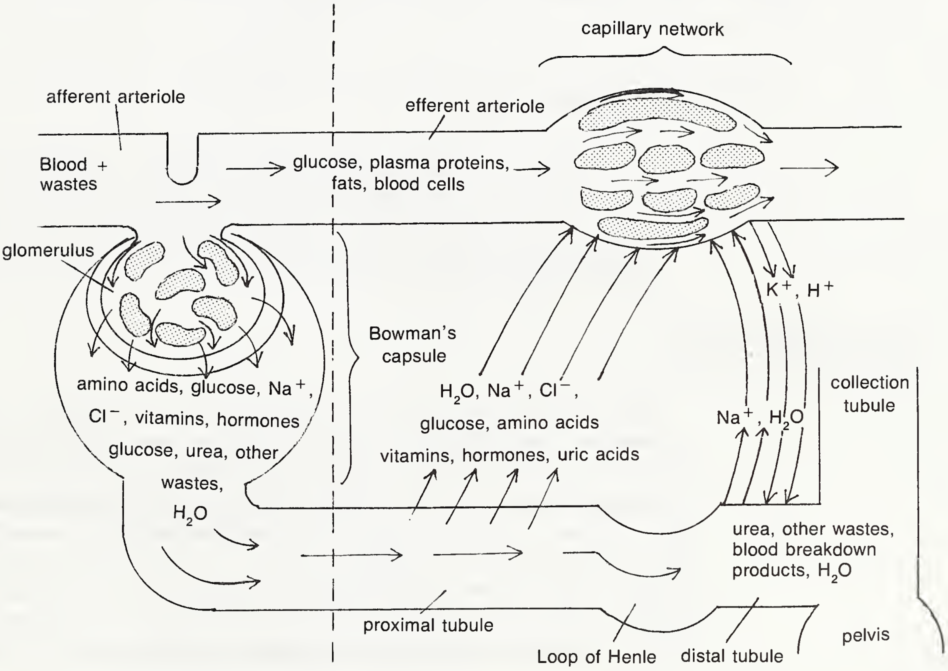
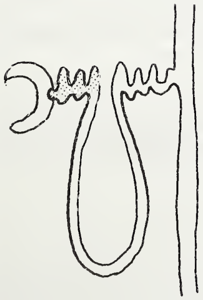
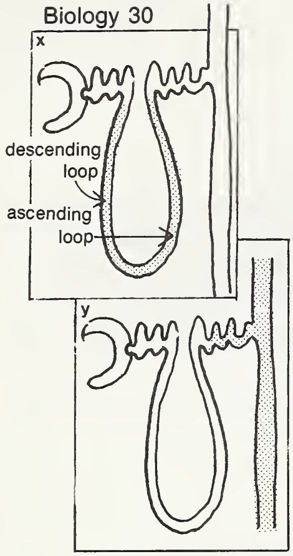

capillary network
afferent arteriole
efferent arteriole
Blood + wastes
glucose, plasma proteins, fats, blood cells
glomerulus
Bowman's capsule
amino acids, glucose, Na^+, Cl^-, vitamins, hormones glucose, urea, other wastes, H_2O
H_2O, Na^+, Cl^-, glucose, amino acids vitamins, hormones, uric acids
K^+, H^+
Na^+, H_2O
collection tubule
urea, other wastes, blood breakdown products, H_2O
proximal tubule
Loop of Henle
distal tubule
pelvis
FILTRATION
REABSORPTION

Figure 2: Formation of Urine by Glomerular Filtration and Tubular Reabsorption



In the **proximal convoluted tubule** glucose, amino acids and Na^+ ions are reabsorbed by active transport via special carrier molecules present in the cells lining the tubules. As these substances are removed, the osmotic pressure balance is upset and water leaves the tubules by osmosis. Most nitrogenous wastes like urea are passed to the collecting duct although some uric acid may pass from the proximal tubules by diffusion.



[x]In the **Loop of Henle** more Na^+ ions are reabsorbed by active transport into the capillaries. This reabsorption is stimulated by the adrenal cortical hormone, **aldosterone**. As more Na^+ is pumped out, more water is reabsorbed by osmosis. The osmotic pressure is greatest at the bottom of the Loop of Henle. No water can leave the ascending Loop of Henle because it is impermeable to water.

[y]Further reabsorption of water takes place in the **distal convoluted tubule** and **collecting duct** under the influence of **antidiuretic hormone** (ADH) produced by the posterior pituitary. This hormone increases the permeability of these tubules to water so most of the remaining water is reabsorbed.

In a deficiency disease of ADH known as **diabetes insipidus**, no further absorption of water takes place after the Loop of Henle and about 18 L of urine are formed per day instead of the usual 1 to 1.5 L.

C. Tubular Secretion

A few substances enter the urine in the tubules from the blood by secretion from the tubular cells. Some unusual substances such as drugs like penicillin are secreted this way. In addition, potassium ions, hydrogen ions and ammonia are secreted to help regulate the acid-base balance of the body. The pH of urine is usually about 6, depending upon a person's diet.

Urination (Micturation)

Urine passes down the collecting ducts, into the renal pelvis, to the **ureters** and into the **bladder**. The bladder is made of very elastic tissue which can hold up to 1 L of urine if necessary. At about 400 mL, a reflex central mechanism governed by the parasympathetic nervous system stimulates the bladder to contract and the **internal sphincter muscles** relax. Urine is passed, however, only when the **external sphincter muscles** are relaxed as well. These muscles are under conscious control so urination can be avoided until conditions are favorable. The voluntary control of the external sphincter is a learned response that is absent in babies and lost in an individual with a severed spinal cord. In these cases the spinal reflex takes over. Urine passes through the **urethra** to the outside of the body.

Abnormal Kidney Function and Renal Failure

The kidneys have a large built-in safety factor and the functioning of less than one quarter of the nephrons may be adequate. Many conditions may cause kidney failure, such as tubules damaged due to mercury or other heavy metals or infectious diseases. The tubules may also become blocked.

If complete kidney failure arises, wastes and acids in the blood build up to toxic levels. Water may also accumulate in the body causing **edema**. In severe cases, kidney failure leads to coma and death.

When both kidneys fail, it is possible to survive if you pass your blood through **dialysis fluid** in an artificial kidney machine. Read pages 386 and 387 of your textbook for an understanding of how an artificial kidney machine works.

Exercise 2

Circle the correct letter (T or F) to indicate whether the following statements are True or False.

T F 1. Water usually leaves nephron tubules by active transport.

T F 2. Sodium ions are pumped out of the filtrate by active transport.

T F 3. Chloride ions follow sodium ions by diffusion.

T F 4. The Loop of Henle is the site of most water reabsorption.

T F 5. Some parts of the nephron are impermeable to water.

T F 6. Inhibition of aldosterone would inhibit Na^+ reabsorption.

T F 7. In diabetes insipidus, less ADH is produced.

T F 8. In a normal kidney, no food molecules are found in the urine.

T F 9. Hydrogen and ammonia are added to the urine by tubular secretion.

T F 10. Micturation is solely a reflex action.

Please check your work with the answers given on page 8.

ANSWERS TO THE KEYED EXERCISES

Exercise 1, pp. 3-4

Part One: True or False

1. **False -** Excretion is used for the excretion of all metabolic wastes from any part of the body.
2. **True**
3. **True**
4. **True**
5. **False -** The kidney retains a homeostatic amount of salt no matter how much you eat.
6. **False -** The kidneys lie about 30 cm above the bladder under the ribs on the back of the abdominal cavity.
7. **False -** The unit of structure of the kidney is the **nephron**.

Part Two: Matching

J	Outer edge of the kidney
B	Located in the renal medulla
E	Blood supply of the nephron
A	Tubular structure near Bowman's capsule
G	Tube leading from excretory system to the outside of the body
C	Tubular structure leading to the collecting duct
H	Urine is stored here
K	Blood vessel entering the glomerulus
L	Blood vessel leaving the glomerulus
N	Blood vessel leaving the kidney

A. Proximal convoluted tubule
B. Loop of Henle
C. Distal convoluted tubule
D. Bowman's capsule
E. Glomerulus
F. Ureter
G. Urethra
H. Bladder
I. Renal Medulla
J. Renal Cortex
K. Afferent arteriole
L. Efferent arteriole
M. Rental artery
N. Renal vein

Exercise 2, p. 7

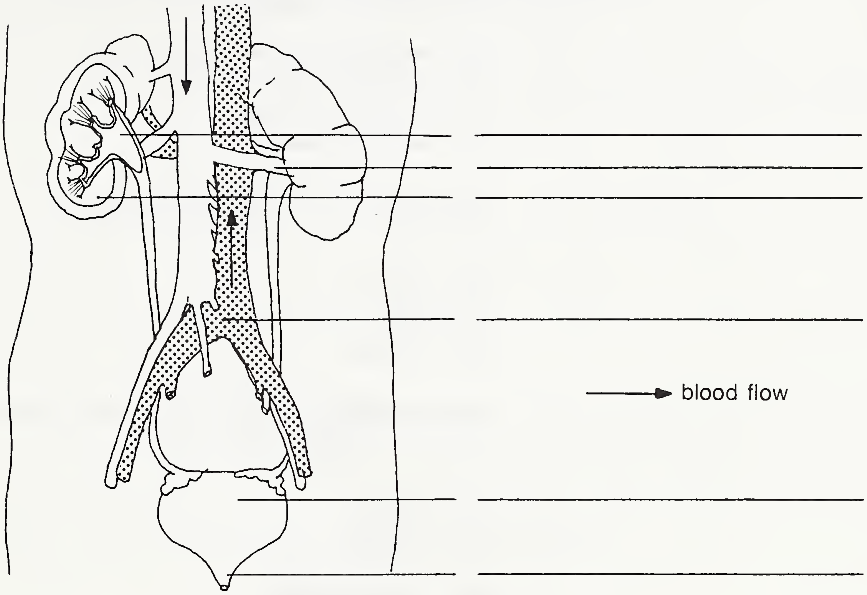
True or False

1. **False -** Water leaves nephron tubules by **osmosis**.
2. **True**
3. **True**
4. **False -** The **proximal tubule** is where most water is reabsorbed.
5. **True**
6. **True**
7. **True**
8. **True**
9. **True**
10. **False -** The internal sphincter is governed by a reflex but the external sphincter is under voluntary control.

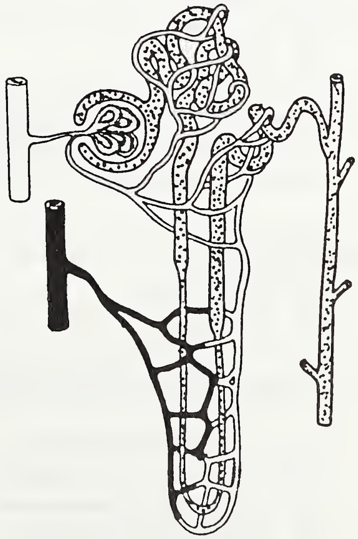
EXERCISES TO BE SENT IN FOR CORRECTION

Exercise 1 - Structure of the Human Kidney

1. The diagram below shows a posterior view of the excretory system. Indicate the names of the structures shown.



2. The drawing below shows a diagramatic representation of a nephron. Label the following structures: afferent arteriole, efferent arteriole, Bowman's capsule, glomerulus, proximal tubule, distal tubule, capillary network, loop of Henle, and collecting tubule.



Exercise 2 - Multiple Choice

In each of the following questions, choose the best answer and write the appropriate letter in the blank provided.

______ 1. The function of the kidney is to regulate

(a) salt and water levels of the body.
(b) acidity of the blood.
(c) excretion of waste products.
(d) all of the above

______ 2. Glomerular filtrate is almost identical to

(a) urine.
(b) plasma.
(c) urea.
(d) uric acid.

______ 3. Which of the following blood components is taken in the nephric capsule by force filtration?

(a) glucose
(b) platelets
(c) red blood cells
(d) plasma proteins

______ 4. More urea would be produced if your diet contained a lot of

(a) chocolate bars.
(b) cookies.
(c) roast beef.
(d) salad.

______ 5. A sample of bladder urine contained 180 units of urea, 0 units of glucose, 0 units of amino acids, and 10 units of proteins. What component is found in abnormal amounts?

(a) urea
(b) glucose
(c) amino acids
(d) proteins

______ 6. A high level of antidiuretic hormone (ADH) in the blood would cause

(a) increased urea formation.
(b) decreased urea formation.
(c) formation of concentrated urine.
(d) formation of dilute urine.

______ 7. In a kidney nephron, filtration of blood plasma occurs between the

(a) renal arteriole and glomerulus.
(b) loop of Henle and capillary network.
(c) distal tubule and collecting duct.
(d) Bowman's capsule and proximal tubule.
(e) glomerulus and Bowman's capsule.

______ 8. Which substance is completely reabsorbed into the blood plasma?

(a) amino acids
(b) uric acid
(c) protein
(d) salts

______ 9. Aldosterone is produced by the

(a) kidneys.
(b) anterior pituitary.
(c) adrenal cortex.
(d) renal medulla.

______ 10. A deficiency in aldosterone would cause

(a) an increase in Na^+ reabsorption.
(b) a decrease in Na^+ reabsorption.
(c) a decrease in water reabsorption.
(d) (b) and (c)

______ 11. Excessive alcohol consumption inhibits ADH. The consequence is

(a) decreased Na^+ reabsorption.
(b) decreased electrolyte secretion.
(c) increased water in the urine.
(d) vomiting and diarrhea.

______ 12. Water moves across the cell membranes of the nephron by

(a) diffusion.
(b) active transport.
(c) osmosis.
(d) forced filtration.

______ 13. The skin excretes a solution of dilute

(a) salts.
(b) urea.
(c) uric acid.
(d) urine.

______ 14. Stimulation of the bladder by parasympathetic fibers of the nervous system produces

(a) contraction of the bladder and relaxation of the internal sphincter.
(b) relaxation of the bladder and contraction of the internal sphincter.
(c) contraction of the internal and external sphincters.
(d) relaxation of the bladder and both sphincters.

Exercise 3 - Control of the Kidney

1. What is the relationship between the quantity of vasopressin (ADH) and the quantity of urine?

(a) Too much ADH?

____

____

____

____

(b) Too little ADH?

____

____

____

____

2. Explain the role of aldosterone in the production of urine.

Exercise 4 - The Artificial Kidney

1. The kidney machine withdraws blood from which type of blood vessel?

2. What is dialysis?

3. Which substances are allowed to pass through the dialysis tubing to be discarded?

4. The concentration of electrolytes in the fluid bath and plasma would be the (same or different) ____________________ .

5. Blood from the kidney machine would be returned to which blood vessel?

Please submit pages 9 to 13 for correction.

END OF LESSON 14

LESSON RECORD FORM

3230 Biology 30
Revised 03/89

FOR STUDENT USE ONLY

Date Lesson Submitted

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Time Spent on Lesson

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(If label is missing
or incorrect)

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ALBERTA CORRESPONDENCE SCHOOL

MAILING INSTRUCTIONS FOR CORRESPONDENCE LESSONS

1. BEFORE MAILING YOUR LESSONS, PLEASE SEE THAT:

(1) All pages are numbered and in order, and no paper clips or staples are used.
(2) All exercises are completed. If not, explain why.
(3) Your work has been re-read to ensure accuracy in spelling and lesson details.
(4) The Lesson Record Form is filled out and the correct lesson label is attached.
(5) This mailing sheet is placed on the lesson.

2. POSTAGE REGULATIONS

Do **not** enclose letters with lessons.

Send all letters in a separate envelope.

3. POSTAGE RATES

First Class

Take your lesson to the Post Office and have it weighed. Attach sufficient postage and a **green first-class sticker to the front of the envelope, and seal the envelope. Correspondence lessons will travel faster if first-class postage is used.**

Try to mail each lesson as soon as it has been completed.

When you register for correspondence courses, you are expected to send lessons for correction regularly. Avoid sending more than two or three lessons in one subject at the same time.

OBJECTIVES

After completing this lesson you should be able to:

1. **Label** a diagram of the male reproductive system.
2. **Identify** and describe the organs of the male reproductive system.
3. **Explain** the structure and function of the male reproductive organs.
4. **Describe** the production of sperm and the detailed structure of a sperm cell.
5. **Explain** the role of the accessory glands in the production of semen.
6. **Describe** the structure and processes that enable erection to take place.
7. **Define** puberty and describe the secondary sexual characteristics which develop in the sexes.
8. **Label** a diagram of the female reproductive system.
9. **Describe** the structure and function of the female reproductive organs.
10. **List** and describe the hormones involved in the development of secondary sexual characteristics.
11. **List** and describe the functions of the 4 hormones involved in menstruation.
12. **Describe** the changes that take place in the ovaries and uterus during the menstrual cycle.
13. **Know** the structure and function of the mammary glands.
14. **Know** the processes involved in copulation and fertilization.
15. **Know** and describe various methods of birth control.
16. **List** the major sexually transmitted diseases and state their symptoms.
17. **Define** the term, menopause.

The symptoms of non-specific urethritis, when present, resemble those of gonorrhea: painful, burning urination, the need to urinate frequently and sometimes a cloudy, mucus discharge. Only a laboratory analysis of this discharge can determine which disease the infected person has (NSU or gonorrhea). NSU is not as dangerous as syphilis or gonorrhea because it does not spread to other regions of the body and there are usually no long term effects of the disease. In rare instances, however, NSU can cause blockages in the fallopian tubes, leaving the infected woman sterile. Complications can also arise in pregnant mothers, as the bacteria can be passed on to the infant during birth, infecting the eyes.

Antibiotics are prescribed to clear up the infection.

Scabies

Scabies is a severe skin condition caused by a tiny species of mite which lives on or around the genitals. These mites are wingless and cannot cover large distances by themselves. Hence, the mites can only be transmitted by close contact with an infected person, their clothes or their bed linen.

Scabies mites cause intense itching of the skin. The itching is due to the habits of the female mites. The female mite burrows in the epidermis of the skin to lay eggs. One female mite may deposit 2 or 3 eggs under the skin each day for 4 to 5 weeks.

The symptoms of scabies will probably not become noticeable until about 4 to 6 weeks after the initial infestation. It takes this long to build up a significantly large population of mites. All the tunneling by the female mites causes the skin to become hypersensitive, and intense itching develops. The itching is generally worse in warm conditions and may be so severe that the host (infected person) is unable to sleep at night.

Scabies mites and their eggs can be eliminated with the use of a medicated shampoo, especially formulated for this purpose.

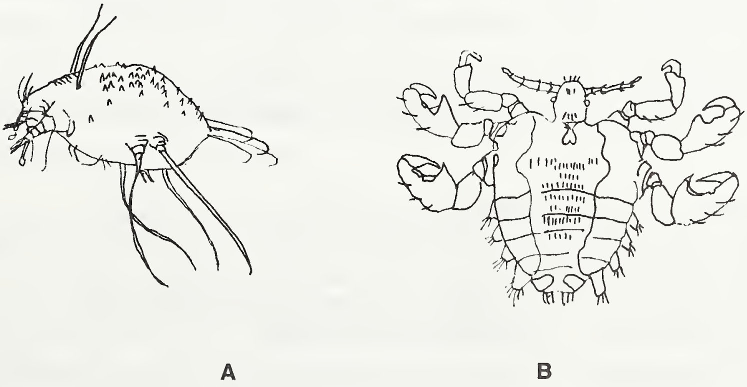


Figure 5: Highly magnified diagrams of a (A) Scabies mite and a (B) Pubic louse.

Pubic Lice - "Crabs"

These are blood sucking lice that are usually found in the genital region of the body. They are clearly visible, if closely examined, being about 1 to 2 mm across. These lice are slow moving, wingless creatures, which spend most of their time clinging to hairs.

Pubic lice are transmitted when a person has sexual contact with an infected individual. Since the lice are strongly attached to hairs, they are rarely transmitted by bedding or clothing.

As with scabies, a pubic louse infestation will probably go unnoticed for several weeks. Again, the lice are not usually noticeable until there is a significantly large population of them. Pubic lice feed on blood and cause itching because of these feeding habits.

A medicated shampoo or lotion can be prescribed by a doctor to kill the lice and their eggs.

Exercise 3

1. Complete the following statements by filling in the numbered blank on the right.

(a) The process by which sperm are deposited in the vagina of a female is known as (1) or (2) (2) .

(b) (3) is defined as the union of a sperm and ovum.

(c) The period marking the end of the female reproductive life is known as (4) .

(d) (5) is the most serious sexually transmitted disease.

(e) Only a laboratory analysis of the discharge can determine whether a person has non-specific urethritis or (6) .

(f) (7) is a severe skin condition caused by a tiny species of mite.

(g) "Crabs" are blood sucking (8) usually found in the genital region of the body.

(h) (9) (9) is a sexually transmitted disease with no known cure.

(i) During menopause the (10) and (11) eventually shrink and the woman becomes infertile.

1. ____________________
2. ____________________
3. ____________________
4. ____________________
5. ____________________
6. ____________________
7. ____________________
8. ____________________
9. ____________________
10. ____________________
11. ____________________

The spermatozoa must make their way through the uterus, into the fallopian tubes, and hopefully meet an ovum in the upper one-third of the fallopian tube. The spermatozoa possess long, whip-like flagella to propel themselves along. The movement of the sperm is also aided by muscular contractions of the uterus and fallopian tubes.

At best, out of the millions of sperm released at orgasm, only a few thousand will reach the ovum. All of these sperm then contribute the enzymes necessary to dissolve part of the membrane surrounding the ovum. This then allows one sperm to penetrate and fertilize the ovum.

With the penetration of the ovum by one sperm, a barrier is instantly formed preventing penetration by any other sperm. Within the ovum, the genetic material of the sperm unites with the genetic material of the ovum to form a zygote. The zygote possesses the normal, diploid number of chromosomes (23 pairs) and can begin the long developmental processes leading to the birth of a new individual.

Menopause

READ

Read the section of your text dealing with menopause (p. 436).

When a woman reaches middle age (45-50) her ovaries are less responsive to the hormones secreted by the pituitary (FSH and LH). Fewer follicles mature and fewer eggs are released by the ovaries. This insensitivity of the ovaries also results in a drop in the levels of estrogen and progesterone in the blood.

Without the high levels of estrogens and progesterone the uterine lining does not thicken and menstrual bleeding during the menstrual cycle becomes sporatic and eventually stops. The cessation of menstrual bleeding is the first major sign that the woman's reproductive life has come to an end. The period marking the end of the female reproductive life is known as **menopause** or the "**change of life**." Menopause is a transitional stage, similar to puberty, and may last for two or more years.

During menopause the uterus and ovaries eventually shrink and the woman becomes infertile. As a result, the ovaries cease to produce estrogens and progesterone and only small quantities of FSH and LH are produced by the pituitary. These hormonal changes often mean that women experience various side effects during menopause. Hot flashes and emotional problems are the most common symptoms of the change of life. Physical ailments like dizzy spells, headaches, insomnia, fatigue, abdominal bloatedness and weight gain are often blamed on menopause but no real connection has yet been found.

Sexually Transmitted Diseases

READ

Read the section of your text dealing with sexually transmitted diseases (pp. 437 - 441).

A sexually transmitted disease is an infection that is almost always transferred from person to person by sexual contact. A person would most likely catch the infection by having sexual intercourse with a person who has the infection. This happens because:

1. the organisms that cause the infection usually live in or on the infected person's genitals.

2. to infect another person the organisms have to either enter the body (syphilis, gonorrhea, etc.) or be transferred to the skin's surface (scabies, pubic lice). Both of these means of infection are easily accomplished during sexual intercourse.

Other than the method by which they are spread, sexually transmitted diseases have very little in common. Some infections may cause only a bothersome itch; whereas others may, if untreated, cause paralysis, insanity or even death.

Sexually transmitted diseases are now reaching epidemic proportions in North America. Gonorrhea is second only to the common cold as the most treated ailment by doctors. Being so commonplace, many of the sexually transmitted diseases have nicknames by which they are known. Anyone who has "the clap", is informing you that they have gonorrhea. The following is a list of some of the major types of sexually transmitted diseases, along with their abbreviations, common-names or nicknames.

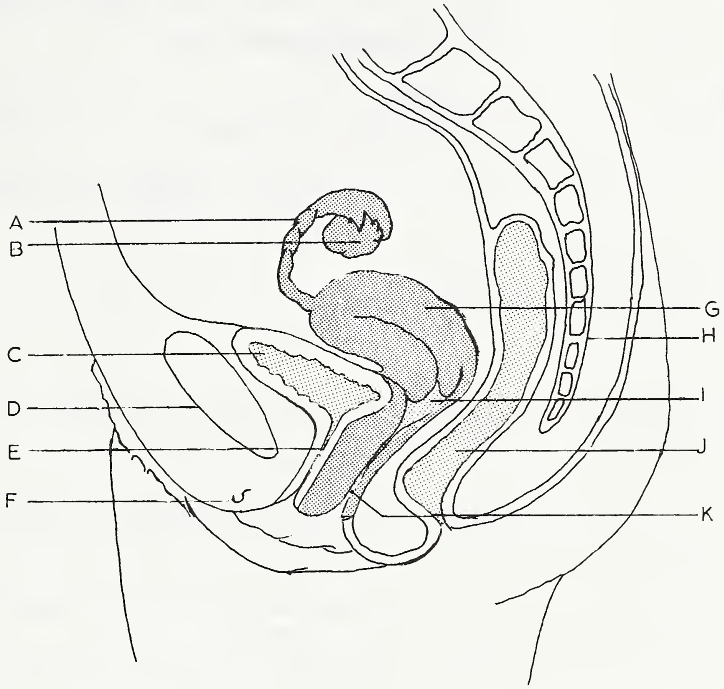
1. Syphilis - "the pox" or "scab" or "syph"
2. Gonorrhea - "the clap"
3. Non-specific urethritis - "NSU"
4. Herpes genitalis - "cold sores"
5. Scabies - "the itch"
6. Pubic lice - "crabs"

Syphilis, gonorrhea and herpes genitalis are all discussed in your text. What follows will be a brief discussion of each of the other more common infections.

Non-specific Urethritis

Non-specific urethritis, also known as non-gonococcal urethritis, is a bacterial infection of the urethra. This sexually transmitted disease affects both males and females, but not all infected persons show any symptoms of the disease. Even though no symptoms are present, infected persons are still able to pass the infection on to their sexual partners.

2. Identify the structures in the following diagram by filling in the letter blanks below.



A. ____________________

B. ____________________

C. ____________________

D. ____________________

E. ____________________

F. ____________________

G. ____________________

H. ____________________

I. ____________________

J. ____________________

K. ____________________

3. Define the term oogenesis.

____

____

____

____

4. The statements given below describe the effects that various hormones have on the female reproductive system. Write the letter of each hormone in the appropriate blank beside each statement. Each letter **may be** used more than once and some statements may have **more than one** answer.

A. Estrogen
B. Follicle stimulating hormone
C. Progesterone
D. Luteinizing hormone

______ stimulates the formation of the corpus luteum after ovulation

______ stimulates the initial development of the ovarian follicles

______ responsible for the development and maintenance of female reproductive structures

______ prepares the breasts to secrete milk

______ brings about ovulation

______ produced by the corpus luteum to maintain the uterine lining after ovulation

______ high levels of this hormone inhibit FSH secretion by the pituitary

______ low levels of this hormone cause the shedding of the endometrium

______ the hormones which are produced by the pituitary

______ the hormones which are produced by the ovaries

Please check your work with the answers given on pages 18 - 19.

Copulation and Fertilization

READ

Read the section in your text dealing with copulation and fertilization (pp. 434 - 436).

For the fertilization of a mature ovum to occur, sperm must be transferred from the male to the female. The process by which spermatozoa are deposited in the vagina of a female is known as **copulation** or **sexual intercourse**.

When the male ejaculates during sexual intercourse, sperm and seminal fluid are deposited in the vagina, near the opening of the uterus (the cervix). Once released, the sperm are then in a race against time, having only a brief lifetime of 24 to 36 h to find a mature ovum.

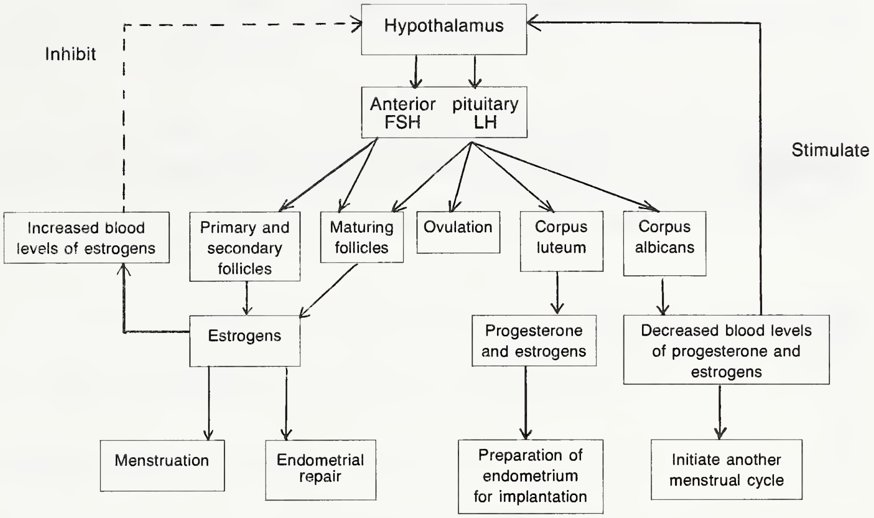

Inhibit
Hypothalamus
Stimulate
Anterior pituitary
FSH
LH
Increased blood levels of estrogens
Primary and secondary follicles
Maturing follicles
Ovulation
Corpus luteum
Corpus albicans
Estrogens
Progesterone and estrogens
Decreased blood levels of progesterone and estrogens
Menstruation
Endometrial repair
Preparation of endometrium for implantation
Initiate another menstrual cycle

Figure 3: Hormonal interactions of the menstrual and ovarian cycles

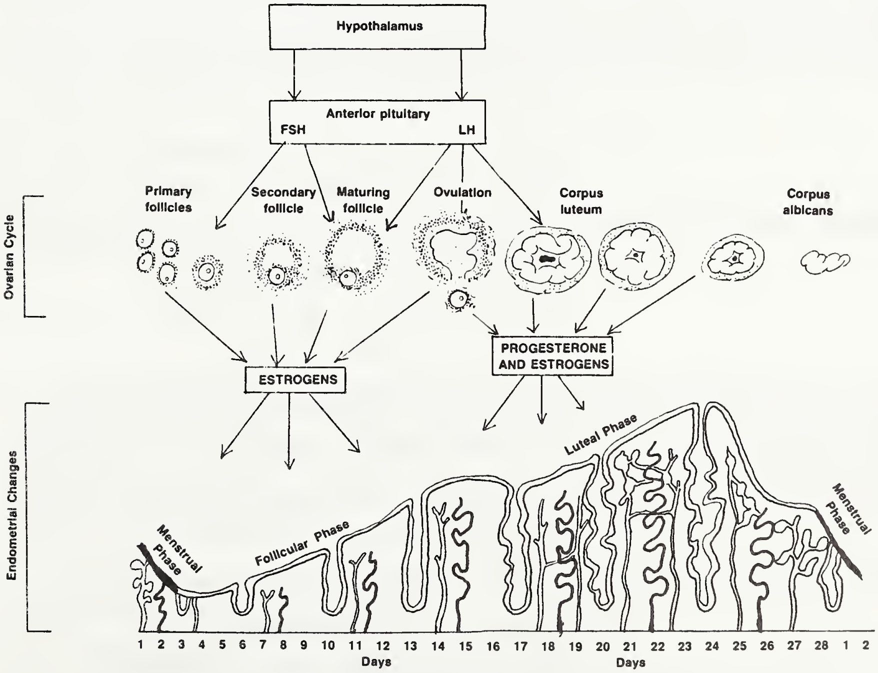


Figure 4: Summary of the developments of the menstrual and ovarian cycles including the hormonal secretions. In the cycle shown, fertilization and implantation have not occurred.

E. The Mammary Glands

Review the section of your text that deals with the mammary glands (p. 433).

Exercise 2

Use the appropriate sections of your text and lesson notes to answer the following questions.

1. Complete each of the following statements by filling in the numbered blank on the right.

   (a) The two ____(1)____ are the primary sex organs of the female.

   (b) Puberty ends with the onset of the first ____(2)____ ____(2)____ (two words).

   (c) The small groups of cells within the ovaries which contain the ova are called ____(3)____ .

   (d) ____(4)____ is the process by which a mature follicle bursts through the ovarian membrane.

   (e) The ovarian cycle is influenced by two pituitary hormones; ____(5)____ ____(5)____ hormone and ____(6)____ hormone.

   (f) Once released from the ovary an ovum is drawn into the ____(7)____ ____(7)____ .

   (g) The ____(8)____ is a growth chamber, prepared each month for the arrival of a ____(9)____ ovum.

   (h) The outer layer of the endometrium is shed during the ____(10)____ phase of the menstrual cycle.

1. ____________________

2. ____________________

3. ____________________

4. ____________________

5. ____________________

6. ____________________

7. ____________________

8. ____________________

9. ____________________

10. ____________________

Note that each primary oocyte which undergoes meiosis gives rise to only **one** mature ovum. This differs from meiosis in males, where each primary spermatocyte gives rise to four spermatozoa.

The germ cells which produce the female gametes undergo uneven cell divisions during meiosis. With each cell division, one daughter cell retains almost all of the cytoplasm. The other daughter cell, containing only nuclear material, is called a polar body. Polar bodies cannot function without cytoplasm and thus die within a short period of time. The cell which has retained all of the cytoplasm throughout the meiotic divisions becomes the mature ovum.

This method of cell division during meiosis ensures that at least one ovum will have sufficient internal cytoplasmic reserves to survive the early stages of development. A fertilized ovum cannot draw on an external source of nutrients until it becomes imbedded in the uterine wall.

D. Hormonal Control

The menstrual cycle, ovarian cycle and the development of the primary and secondary sexual characteristics of the female are all under hormonal control. The menstrual cycle prepares the endometrium of the uterus each month for the arrival of a fertilized ovum. The ovarian cycle is a monthly series of events associated with the development and release of an ovum. Remember - these events only occur every month if the female is not pregnant. Pregnancy suspends both the menstrual and ovarian cycles for the duration of the gestation period and until after birth. Breast-feeding also inhibits the reestablishment of the menstrual and ovarian cycles for a few months after birth.

REVIEW

Review the sections in your text dealing with the ovarian and menstrual cycles, including their hormonal controls (pp. 423 - 425 and 427-431).

Under the direction of the hypothalamus the anterior pituitary regularly releases varying levels of FSH and LH. These hormones in turn stimulate the release of the ovarian hormones **estrogen** and **progesterone**. These hormones all undergo cyclic fluctuations, corresponding to various stages in the monthly ovarian and menstrual cycles. This is in contrast to the situation in males where the major hormone, testosterone, is constantly being produced at relatively stable levels.

The following is a summary of the actions and interactions of the hormones involved in the ovarian and menstrual cycles.

1. **Follicle Stimulating Hormone (FSH)**
   - stimulates the initial development of the ovarian follicles
   - stimulates the secretion of estrogens by the follicles
   - high levels of estrogens inhibit FSH secretion by the anterior pituitary
   - low levels of progesterone and estrogen at the end of the menstrual cycle stimulate the hypothalamus to increase FSH secretion, renewing the cycle

2. **Luteinizing Hormone (LH)**

- stimulates further development of the ovarian follicles
- brings about ovulation
- stimulates the formation of the corpus luteum after ovulation, thereby increasing the production of estrogens and progesterone
- is inhibited by high levels of progesterone and estrogens which are produced by the corpus luteum
- lower levels of LH result in the degeneration of the corpus luteum resulting in the formation of the corpus albicans

3. **Estrogens -** the hormones of growth

- responsible for the development and maintenance of female reproductive structures, especially the lining of the uterus, secondary sexual characteristics and the breasts
- prepare the endometrium of the uterus for the arrival of a fertilized ovum
- high levels of estrogens inhibit FSH secretion just before ovulation, resulting in a drop in the estrogen level at ovulation. (This inhibition of FSH provides the basis for the action of one kind of contraceptive pill.)
- are produced by the corpus luteum to maintain the uterine lining after ovulation
- if fertilization and implantation fail to occur the corpus luteum degenerates, resulting in the shedding of the endometrial wall because of low estrogen levels
- low estrogen levels during the menstrual phase act as a stimulus for FSH secretion by the anterior pituitary. The estrogen level then increases to rebuild the endometrium of the uterus and begin the menstrual cycle again.

4. **Progesterone -** the hormone of maturation

- works with estrogens to prepare the endometrium for the implantation of a fertilized ovum
- prepares the breasts to secrete milk
- is produced by the corpus luteum after ovulation to maintain the endometrium
- if no fertilization occurs, the rising levels of progesterone and estrogen inhibit LH secretion by the pituitary
- the corpus luteum then degenerates, resulting in falling levels of progesterone and estrogens
- the low levels of progesterone and estrogens result in the menstrual phase during which the endometrium is shed

Study the following diagrams carefully, reviewing your lesson notes and textual material to ensure a good understanding of the sequence of events that occur in both the menstrual and ovarian cycles. Special emphasis should be placed on learning the actions and interactions of the hormones involved.

The Female Reproductive System

READ

Read the sections of the text dealing with the female reproductive system (pp. 423 to 433).

A. Puberty

Puberty is that period of development which prepares a person for adulthood. During this period of time primary and secondary sexual characteristics develop and mature. In females, the most important changes which occur include the maturation of the ovaries and the initiation of menstruation.

The changes that take place at puberty are governed by the hypothalamus. The hypothalamus stimulates the pituitary gland to secrete the hormones FSH (follicle stimulating hormone) and LH (luteinizing hormone).

FSH stimulates the growth of the follicles containing ova in the ovaries. Stimulated by FSH, the follicles produce another hormone, estrogen, which aids in the development of the secondary sex characteristics.

In girls, puberty may begin at any time between the ages of 9 and 14 and end between 14 and 18. The following is a summary of the changes which take place.

1. hair under the arms and in the pelvic region begins to grow.
2. the uterus and vagina mature and increase in size.
3. the breasts increase in size and develop tissues for future milk production.
4. the hips widen, to provide an opening in the pelvic arch large enough to permit the passage of the fetus at birth.
5. the body becomes more full and rounded; due to the deposition of fat beneath the skin.
6. the voice deepens slightly.
7. the vaginal walls thicken and menstruation begins.
8. the body undergoes a period of rapid growth; the average female attaining her full height and almost her full weight by the age of 18.

The end of puberty, in females, is marked by the first menstrual period. This development indicates that the female is now sexually mature, with ovaries producing ova and a menstrual cycle which prepares the uterus for the arrival of a fertilized ovum.

B. Anatomy

Review the diagrams on pages 425 and 426 of your text while reading the following lesson notes.

The female reproductive system consists of the **ovaries** (egg-producing structures) and the apparatus necessary to facilitate the fertilization and development of the ovum (egg). The female reproductive system is more complex than the male reproductive system because of the added responsibility of nuturing the fertilized ovum through its nine month developmental period.

Once a female has matured sexually, one ovum (egg) is usually released from one of the ovaries every month. The released ovum is drawn into the **fallopian tube** (or oviduct) by a current established by the **fimbrae**. The ovum itself is immobile, being transported the length of the fallopian tube by the actions of cilia and by smooth muscle contractions.

The fallopian tube conveys the ovum to the **uterus**. The uterus is essentially a growth chamber, prepared each month for the arrival of a fertilized ovum. An unfertilized ovum will pass through the opening of the uterus (the **cervix**) and proceed along the **vagina** to the exterior. A fertilized egg will become implanted in the uterine wall and continue to develop and mature. This development will be dealt with in Lesson 16.

C. The Production of Ova

The two ovaries are the primary sex organs of the female. This means that the ovaries are responsible for the production of gametes (the sex cells or ova). The process by which germal, diploid cells undergo meiosis in order to produce haploid gametes is known as oogenesis. See Figure 2.

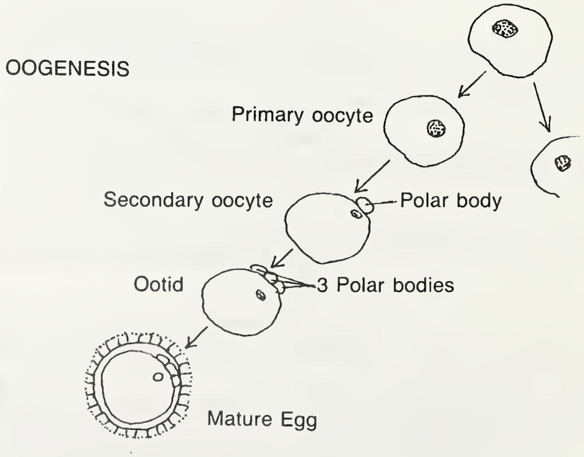


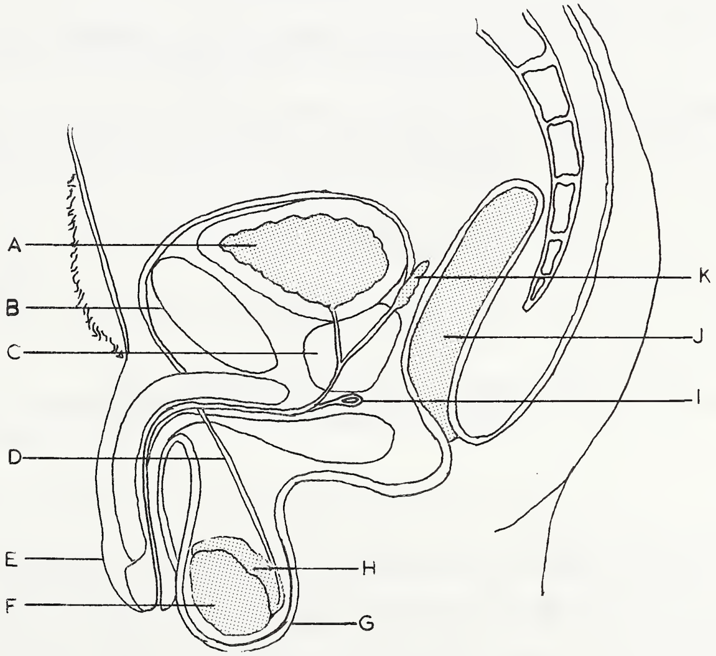
Figure 2: Oogenesis, resulting in one ovum and three polar bodies.

Testosterone is responsible for the growth spurt experienced by boys at puberty. Testosterone is also essential for the maturation of the male sex organs and for the development of the secondary sex characteristics. Under the influence of testosterone the shoulders broaden, the larynx enlarges causing the voice to deepen, and there is an increase in muscle size and strength. Testosterone also promotes the growth of facial and body hair and it causes abnormal secretion by the sebaceous glands of the skin, leading to acne and other skin blemishes. Not only does testosterone initiate physical changes, but also behavioral changes. Moody, aggressive behavior is attributed to the high levels of testosterone in the blood during puberty.

Exercise 1

Complete the following questions using your lesson notes and the information given in your text (pp. 416 - 422).

1. Identify the structures in the following diagram by filling in the letter blanks below.



A. ______________________

B. ______________________

C. ______________________

D. ______________________

E. ______________________

F. ______________________

G. ______________________

H. ______________________

I. ______________________

J. ______________________

K. ______________________

2. Complete the following statements by filling in the numbered blanks on the right with the correct word.

   (a) The ___(1)___ in the male carries both urine from the bladder and semen from the reproductive organs.

   (b) The ___(2)___ conveys sperm from the epididymis to the ejaculatory duct.

   (c) The seminal vesicles secrete a fluid which contains large amounts of the monosaccharide ___(3)___ .

   (d) The ___(4)___ cells provide nourishment and anchor developing sperm.

   (e) ___(5)___ is a mixture of sperm and all the secretions of the accessory glands.

   (f) Sperm produced in the seminiferous tubules collect and mature in the ___(6)___ .

   (g) The full name of the male gamete is ___(7)___ , which is commonly abbreviated to sperm.

   (h) Secretions from the prostate gland help to make the semen ___(8)___ .

   (i) The ___(9)___ is the external organ of the male reproductive system.

   (j) Testosterone is produced by the ___(10)___ cells of the testes.

   1. ____________________
   2. ____________________
   3. ____________________
   4. ____________________
   5. ____________________
   6. ____________________
   7. ____________________
   8. ____________________
   9. ____________________
   10. ____________________

3. List four secondary sex characteristics which develop in males with the onset of puberty.

   (a) ____

   (b) ____

   (c) ____

   (d) ____

4. Define the term, spermatogenesis.

   ____

   ____

   ____

Please check your answers with those given on page 18.

THE REPRODUCTIVE SYSTEM

Introduction

Biologically, the success of any individual in a population is directly related to the number of fertile offspring that individual produces. For an offspring to be successful it must be able to survive to maturity and reproduce. An individual who produces successful offspring has passed on inheritable traits (via genes) to succeeding generations.

Humans reproduce by a process known as sexual reproduction. The sexes are separate, which means that each individual contains either male or female reproductive organs.

The primary reproductive organs are known as **gonads**. These include the testes in males and the ovaries in females. In both sexes the gonads serve dual functions,

1. production of the reproductive cells (sperm or ova)
2. secretion of sex hormones.

In both sexes there are numerous accessory reproductive organs, including ducts for the movement of the sex cells, and accessory glands.

In this lesson we will examine the male and female reproductive systems, the sex hormones, puberty, menopause, the menstrual cycle, copulation and fertilization, contraceptive methods and sexually transmitted diseases.

The Male Reproductive System

Read the chapter introduction and the sections dealing with the male reproductive system (pp. 416 - 422).

The male reproductive system consists of the testes (sperm-producing organs) and the apparatus necessary to convey sperm safely into the female reproductive tract. Sperm cells formed in the seminiferous tubules gather and mature in the epididymis. Mature sperm are moved along the length of the vas deferens to the ejaculatory duct - the opening to the urethra. Accessory glands, including the seminal vesicles, prostate and Cowper's glands, provide a nutritious fluid medium for the sperm. At sexual climax, ejaculation occurs and strong muscular contractions force the sperm and seminal fluid in the vas deferens and epididymis through the urethra and out to the exterior.

A. The Production of Sperm

Sperm production does not begin until a male reaches puberty. Before the onset of puberty, the seminiferous tubules within the testes are solid and the interstitial cells are not producing testosterone.

At puberty, hormones secreted by the anterior pituitary (FSH and ICSH) stimulate the seminiferous tubules to develop central cavities. FSH also initiates cell division by the germal cells lining the seminiferous tubules. This begins gamete production within the testes, a process known as **spermatogenesis**.

Spermatogenesis begins as some of the dividing germal cells become primary spermatocytes and undergo meiosis. Each primary spermatocyte that enters meiosis produces four spermatids with the haploid chromosome number. These spermatids mature within the seminiferous tubules and all along the accessory ducts. At maturity the nonmotile spermatids become motile spermatozoa, ready to fertilize the ova.

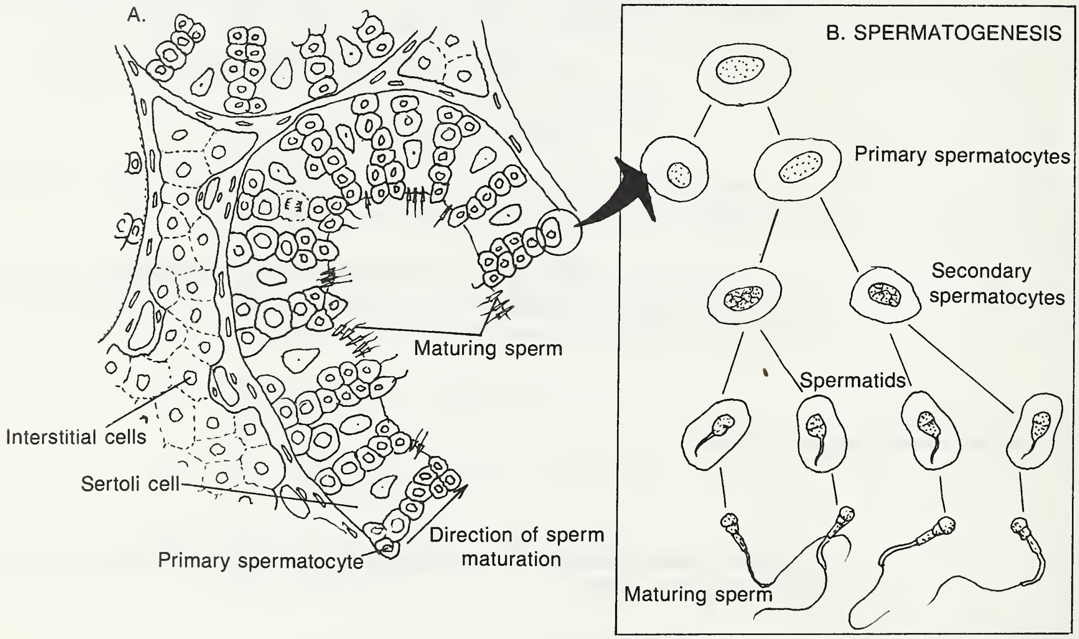


Figure 1: A. A cross section of a seminiferous tubule showing sperm maturation. B. Spermatogenesis, illustrating the process of meiosis in the male, resulting in the production of four haploid spermatozoa.

B. The Role of Testosterone

The other gonadotropic hormone secreted by the anterior pituitary at the onset of puberty is Interstitial Cell Stimulating Hormone (ICSH). This hormone is also found in females but is called luteinizing hormone (LH). The same hormone is given different names because of the different roles it plays in males and females. In the male, ICSH causes the interstitial cells of the testes to produce male sex hormones, principally **testosterone**.

2. Explain why thousands of sperm must gather around an ovum to permit fertilization.

3. Why is syphilis the most serious sexually transmitted disease?

Please check your work with the answers given on page 19.

ANSWERS TO THE KEYED EXERCISES

Exercise 1, pp. 3 - 4

1. Identify the structures.

A. **bladder**
B. **pubic bone**
C. **prostate gland**
D. **vas deferens**
E. **glans or penis**
F. **testis**
G. **scrotum**
H. **epididymis**
I. **Cowper's gland**
J. **rectum**
K. **seminal vesicle**

2. Complete the statements with the words given below.

1. **urethra**
2. **vas deferens**
3. **fructose**
4. **Sertoli**
5. **semen**
6. **epididymis**
7. **spermatozoa**
8. **alkaline**
9. **penis**
10. **interstitial**

3. List four secondary sex characteristics which develop in males with the onset of puberty.

(a) **growth of facial and body hair**
(b) **the shoulders broaden**
(c) **the larynx enlarges**
(d) **there is an increase in muscle size and strength**

4. Define the term, spermatogenesis.

Spermatogenesis is the process by which male gametes (spermatozoa) are produced.

Exercise 2, pp. 10 - 12

1. Complete the statements with the answers provided.

1. **ovaries**
2. **menstrual period**
3. **follicles**
4. **ovulation**
5. **follicle stimulating**
6. **luteinizing**
7. **fallopian tube**
8. **uterus**
9. **fertilized**
10. **menstrual**

2. Identify the structures.

A. **fallopian tube**
B. **ovary**
C. **bladder**
D. **pubic bone**
E. **urethra**
F. **clitoris**
G. **uterus**
H. **vertebral column**
I. **cervix**
J. **rectum**
K. **vagina**

3. Define the term oogenesis.

Oogenesis is the process by which female gametes (ova) are produced in the ovaries.

4. The following statements describe the effects that various hormones have on the female reproductive system. Write the letter of each hormone in the appropriate blank beside each statement. Each letter **may be** used more than once and some statements may have **more than one** answer.

A. Estrogen
B. Follicle stimulating hormone
C. Progesterone
D. Luteinizing hormone

D stimulates the formation of the corpus luteum after ovulation

B stimulates the initial development of the ovarian follicles

A responsible for the development and maintenance of female reproductive structures

C prepares the breasts to secrete milk

D brings about ovulation

A + C produced by the corpus luteum to maintain the uterine lining after ovulation

A high levels of this hormone inhibit FSH secretion by the pituitary

A + C low levels of these hormones cause the shedding of the endometrium

B + D the hormones which are produced by the pituitary

A + C the hormones which are produced by the ovaries

Exercise 3, pp. 16 - 17

1. Complete the statements with the answers given

1. **copulation**
2. **sexual intercourse**
3. **fertilization**
4. **menopause**
5. **syphilis**
6. **gonorrhea**
7. **scabies**
8. **lice**
9. **Herpes genitalis**
10. **uterus**
11. **ovaries**

2. **Thousands of sperm must be present to produce enough of the enzyme necessary to dissolve the ovum's protective membrane.**

3. **Syphilis is the most serious sexually transmitted disease because, if not treated, it spreads throughout the body and can be fatal.**

EXERCISES TO BE SENT IN FOR CORRECTION

Part One: Multiple Choice

For each of the following questions choose the best answer and write the appropriate letter in the blank provided.

______ 1. Which one of the following glands controls the development of the sex organs?

(a) adrenal
(b) pituitary
(c) thyroid
(d) pancreas

______ 2. The endometrium is the lining of the

(a) bladder.
(b) vagina.
(c) uterus.
(d) oviduct.

______ 3. The male pituitary hormone ICSH is also secreted by the female pituitary. In the female, however, this hormone is called

(a) progesterone.
(b) estrogen.
(c) follicle stimulating hormone.
(d) luteinizing hormone.

______ 4. The part of the male reproductive system which conducts both urine and sperm is called the

(a) ureter.
(b) urethra.
(c) epididymis.
(d) vas deferens.

______ 5. The hormone which stimulates the appearance of male secondary sexual characteristics during puberty is

(a) testosterone.
(b) progesterone.
(c) adrenalin.
(d) estrogen.

______ 6. After ovulation, the follicular cells left behind in the ovary form a yellow mass known as the

(a) corpus albicans.
(b) corpus luteum.
(c) endometrium.
(d) primary follicles.

_____ 7. Enzymes required for dissolving the protective barrier of the ovum are located in the part of the sperm known as the

(a) nucleus.
(b) mitochondria.
(c) zygote.
(d) acrosome.

_____ 8. The average female menstrual cycle lasts about

(a) 21 days.
(b) 14 days.
(c) 28 days.
(d) 5 days.

_____ 9. During the average menstrual cycle ovulation occurs on about the

(a) 5th day.
(b) 14th day.
(c) 21st day.
(d) 28th day.

_____ 10. Which of the following is **not** one of the changes which occur in females during puberty?

(a) the hips widen
(b) hair in the genital region begins to grow
(c) the ovaries increase in size
(d) the voice deepens slightly

_____ 11. Sperm are able to move through the uterus, and into the fallopian tubes .

(a) aided by muscular contractions of the uterus.
(b) aided by muscular contractions of the fallopian tubes.
(c) due to a whiplike motion of their flagella.
(d) all of the above

_____ 12. Each primary oocyte which undergoes meiosis gives rise to

(a) four mature ova.
(b) two mature ova.
(c) one mature ovum and three polar bodies.
(d) two mature ova and two polar bodies.

_____ 13. Menstrual bleeding and the menstrual cycle stop during menopause because the ovaries stop secreting

(a) follicle stimulating hormone.
(b) luteinizing hormone and estrogens.
(c) progesterone and follicle stimulating hormone.
(d) estrogens and progesterone.

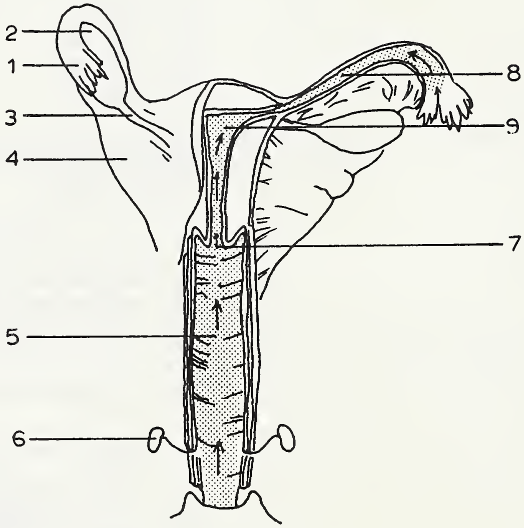
______ 14. Which of the following sexually transmitted diseases is **not** caused by a bacteria or virus?

(a) scabies
(b) gonorrhea
(c) herpes genitalis
(d) syphilis

______ 15. The process known as spermatogenesis takes place in the

(a) ovaries.
(b) epididimis.
(c) testes.
(d) follicles.

Use the following diagram of the female reproductive system to answer questions 16 to 19.



______ 16. Estrogen and progesterone affect the structure labelled

(a) 1
(b) 2
(c) 8
(d) 9

______ 17. The successful fertilization of a mature ovum usually takes place in the

(a) 8
(b) 9
(c) 5
(d) 1

______ 18. A pap smear is a common procedure done to test for cancer of the

(a) 5
(b) 9
(c) 2
(d) 7

______ 19. Female gametes are produced by the

(a) 1
(b) 2
(c) 3
(d) 6

______ 20. The accessory gland of the male which produces a thick, alkaline substance which contains fructose is the

(a) Cowper's gland.
(b) prostate gland.
(c) epididymis.
(d) seminal vesicle.

______ 21. If fertilization of the ovum fails to occur, the corpus luteum will

(a) degenerate, accompanied by a drop in progesterone levels.
(b) degenerate, accompanied by an increase in estrogen levels.
(c) form from the follicle and begin to secrete luteinizing hormone (LH).
(d) form from the follicle and begin to secrete follicle stimulating hormone (FSH).

______ 22. Which of the following hormones stimulates the development of the ovarian follicles and brings about ovulation?

(a) progesterone
(b) luteinizing hormone
(c) estrogens
(d) follicle stimulating hormone

______ 23. Each primary spermatocyte which undergoes meiosis give rise to

(a) four mature spermatozoa.
(b) two mature spermatozoa.
(c) one mature spermatozoa and three polar bodies.
(d) one mature spermatozoa.

______ 24. The interstitial cells of the testes produce

(a) primary spermatocytes.
(b) seminal fluid.
(c) testosterone.
(d) Interstitial Cell Stimulating Hormone.

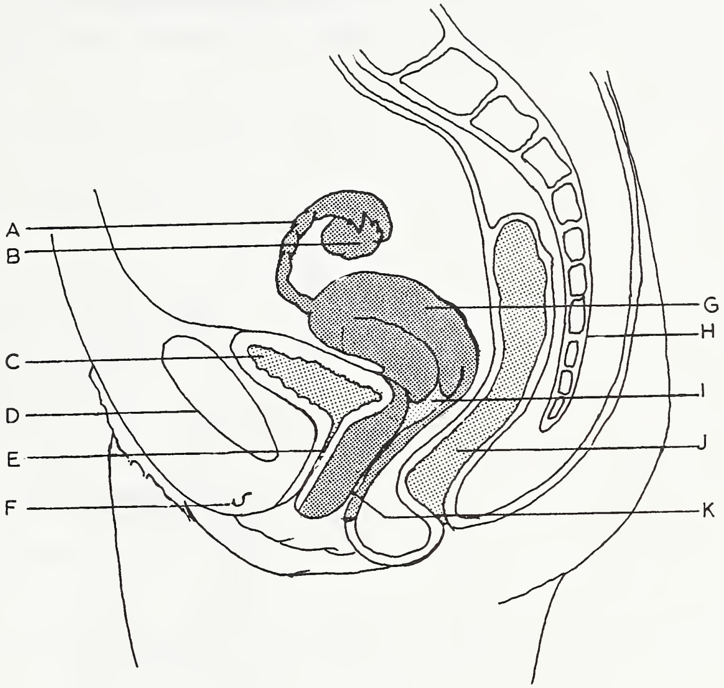
_____ 25. The primary reproductive organs of the male and female are known as the

(a) genitals.
(b) gametes.
(c) glands.
(d) gonads.

Part Two: Matching and Fill-in-the-Blanks

1. Complete the following table by filling in each of the blank squares.

Hormone	Organ where produced	Organ that hormone affects	General effect of the hormone
progesterone			
estrogen			causes endometrium to thicken in preparation for the ovum
FSH	pituitary		
LH			



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2. Match the following statements with the correct part of the female reproductive system by placing the letter from the above diagram in the blank beside each statement. Each letter CAN BE used more than once.

_____ a growth chamber, prepared each month for the arrival of a fertilized ovum

_____ the entrance to the uterus

_____ site of oogenesis

_____ site of fertilization

_____ collecting bag for urine

_____ the organ which receives the penis during intercourse

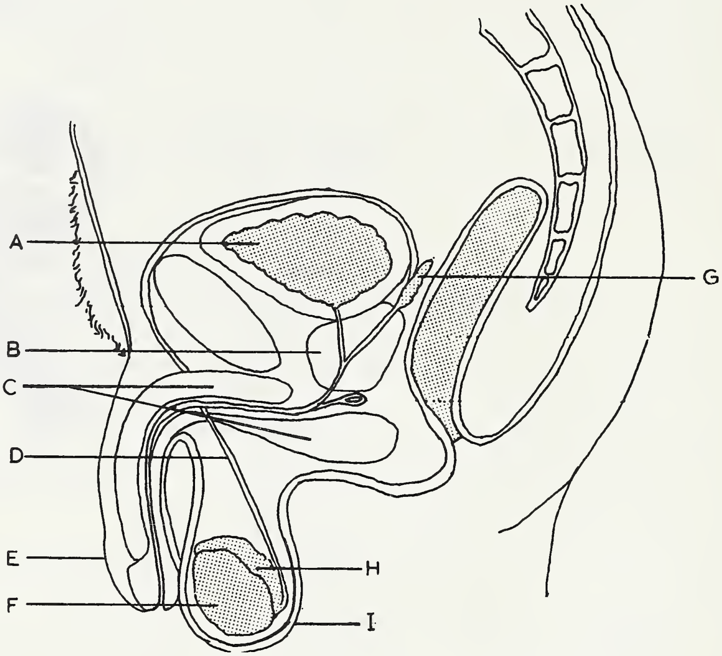
_____ considered to be a vestigial penis

_____ organ stimulated by FSH and LH

_____ organ stimulated by estrogen and progesterone

_____ entrance to the uterus through which sperm must pass

3. Label the following diagram by filling in each of the blanks below with the correct name.



A. ______________________ F. ______________________

B. ______________________ G. ______________________

C. ______________________ H. ______________________

D. ______________________ I. ______________________

E. ______________________

4. Complete the following statements by filling in the numbered blank on the right with the correct word.

(a) The primary stage of the STD ___(1)___ shows up as a sore or chancre, at the place where the germs entered the body. (1) ______________________

(b) The walls of the vagina are lubricated during intercourse by secretions of the ___(2)___ glands.

(c) The initial cell, following the union of a sperm and ovum is called the ___(3)___ .

(d) Milk is secreted from the mammary glands, in a process known as ___(4)___ .

(e) The uterus is made up of three layers: the ___(5)___ , the ___(6)___ and the ___(7)___ .

(f) Developing follicular cells produce the hormone, ___(8)___ which stimulates the thickening of the ___(9)___ .

(g) Contraction of the smooth muscles in the ___(10)___ gland help to push semen out to the exterior during ___(11)___ .

(h) The production of ___(12)___ takes place in the ___(13)___ ___(13)___ of the testes.

(i) The ___(14)___ cells provide nourishment and anchor growing sperm.

(j) Sperm consist of three main parts: the ___(15)___ , ___(16)___ ___(16)___ , and ___(17)___ .

(k) A mature follicle bursts through the ovarian membrane in a process known as ___(18)___ .

(l) The start of the menstrual flow is used to mark the ___(19)___ day of the menstrual cycle.

(m) The period marking the end of the female reproductive life is known as ___(20)___ .

(2) ______________________

(3) ______________________

(4) ______________________

(5) ______________________

(6) ______________________

(7) ______________________

(8) ______________________

(9) ______________________

(10) ______________________

(11) ______________________

(12) ______________________

(13) ______________________

(14) ______________________

(15) ______________________

(16) ______________________

(17) ______________________

(18) ______________________

(19) ______________________

(20) ______________________

Part Three: Short Answer

1. Briefly describe the three phases of the menstrual cycle.

___

___

___

___

___

___

___

2. During menopause, many women experience various physical and emotional problems. Explain why these symptoms occur.

___

___

___

___

___

3. An ovum permits the entry of only one of thousands of sperm surrounding it. Why?

___

___

___

___

Please submit pages 20 to 28 for correction.

END OF LESSON 15

LESSON RECORD FORM

3230 Biology 30
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1. BEFORE MAILING YOUR LESSONS, PLEASE SEE THAT:

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Take your lesson to the Post Office and have it weighed. Attach sufficient postage and a **green first-class sticker to the front of the envelope, and seal the envelope. Correspondence lessons will travel faster if first-class postage is used.**

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When you register for correspondence courses, you are expected to send lessons for correction regularly. Avoid sending more than two or three lessons in one subject at the same time.

OBJECTIVES

Upon completion of this lesson, the student should be able to:

1. **Define** the process of implantation.
2. **Understand** the changes taking place from a fertilized ovum to a blastocyst.
3. **Describe** the components of a blastocyst.
4. **Illustrate** how germ cells are formed.
5. **List** the germ tissues formed and give examples of structures that develop from each.
6. **Understand** placenta formation.
7. **Know** the functions of the placenta.
8. **Outline** major changes in fetal development.
9. **List** the hormones involved in pregnancy and describe the function of each.
10. **Define** gestation and parturition.
11. **Distinguish** between a fetus and an embryo.
12. **Recognize** signs and symptoms of pregnancy.
13. **Know** the hormones involved in the onset of labor.
14. **Outline** the three stages of labor.
15. **Know** variations occur in birth and labor.
16. **Understand** the purpose of Caesarean section delivery.
17. **Distinguish** between true and false labor.
18. **Know** the changes that occur in the woman after birth.
19. **Recognize** benefits and disadvantages of breast feeding and bottle feeding.

PREGNANCY AND CHILDBIRTH

Introduction

Growth is an orderly process whereby cells multiply and differentiate to increase the size and specialization of tissues and organs in an organism. This process is continuous from conception to adulthood to death.

In the process of reproduction, two sex cells, the sperm and the ovum unite to form the zygote which will develop into the embryo. This lesson will deal with growth of the fertilized cell, implantation, development of the embryo and fetus, pregnancy, and the hormones needed to sustain a pregnancy and initiate childbirth. The physical and emotional changes that occur in the pregnant woman will also be studied.

Development From Egg to Fetus

An **ovum** or **egg cell** is barely visible to the naked eye. It is smaller than the period at the end of a sentence. The **sperm cell** is even smaller and about 2500 sperm would be needed to cover a period. Therefore, the combination of a sperm and ovum - the **zygote**, is extremely small, no larger than the point of a very fine needle. Yet, this fertilized cell is capable of producing profound changes in the female body and in itself. As the diagram below illustrates fertilization occurs in the lateral first third of the fallopian tube.

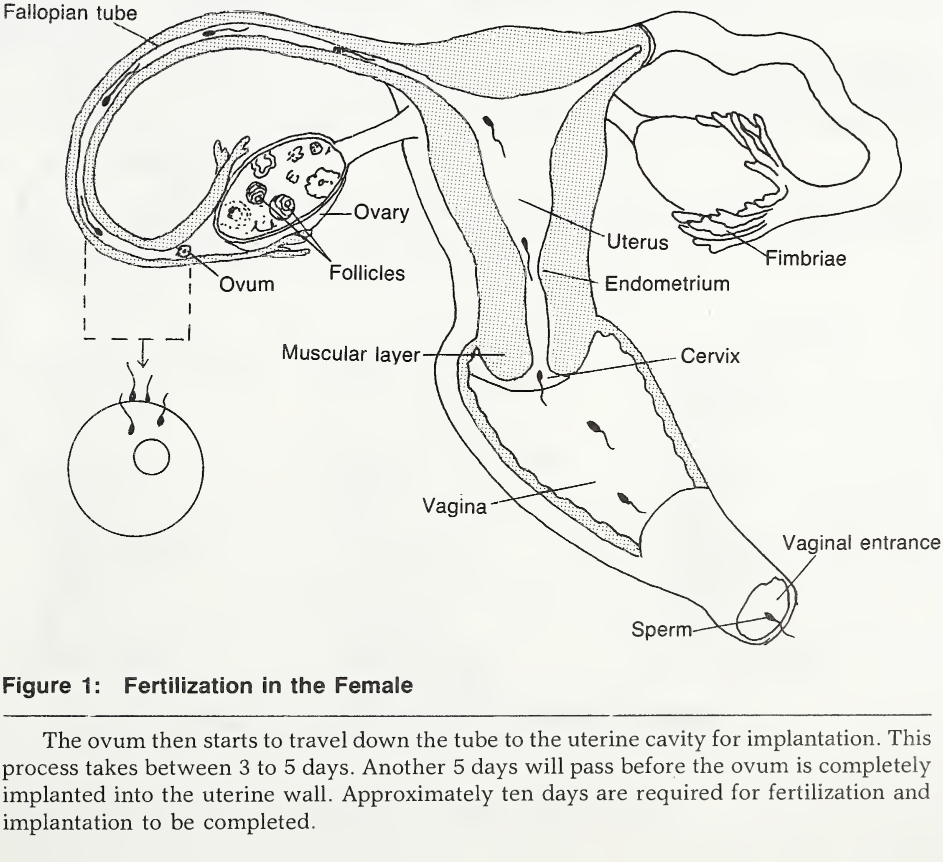


Figure 1: Fertilization in the Female

The ovum then starts to travel down the tube to the uterine cavity for implantation. This process takes between 3 to 5 days. Another 5 days will pass before the ovum is completely implanted into the uterine wall. Approximately ten days are required for fertilization and implantation to be completed.

The following diagram illustrates the changes the zygote undergoes to become an embryo.

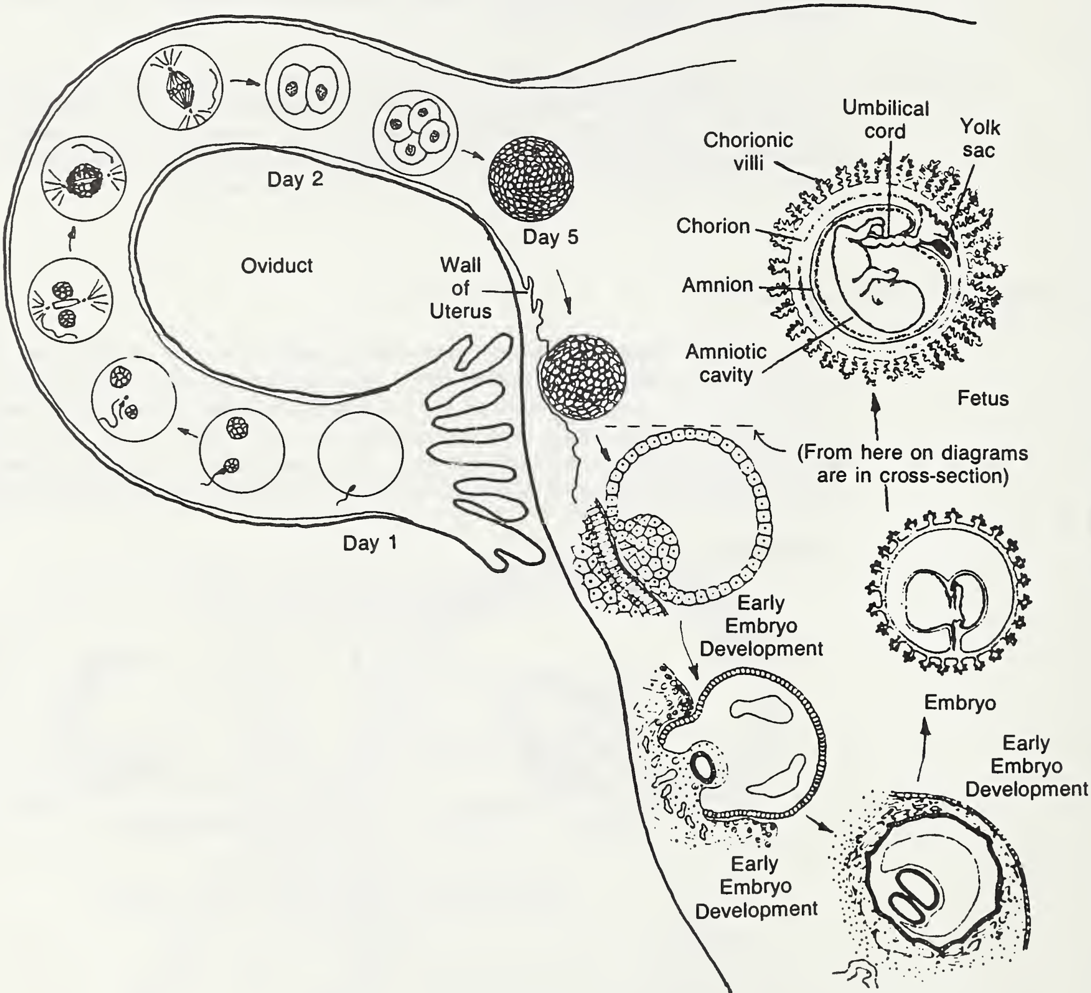
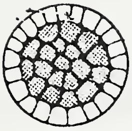
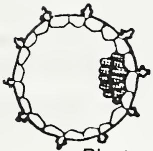


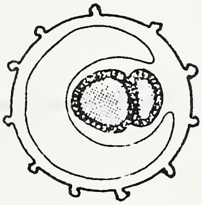
Figure 2: Developmental Changes from Zygote to Embryo



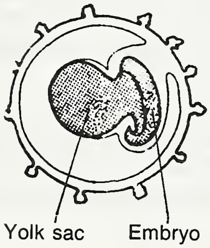
Morula



Blastocyst



Blastocyst forming two cavities



After fertilization, the zygote undergoes mitosis as it travels down the fallopian tubes. The cell divides into two cells 24 hours after fertilization. Within 10 hours a second mitotic division occurs. This stage with 16-32 solid cells is called a **morula**. The process of division continues until a hollow ball of cells is formed called the **blastocyst**. This occurs 5 days after fertilization. The blastocyst is organized into an outer and inner layer of cells. The inner cell mass forms the **embryo**. As specialized tissues develop, the zygote is now called an embryo. Implantation or attachment to the uterus begins. Cells on the outer layer of the blastocyst release enzymes that produce a small cavity in the uterus for implantation. These enzymes destroy cells and blood vessels to accomodate the embryo. Food or nutrients are supplied to the blastocyst as enzymes continue to breakdown the tissue of the mother after implantation. However, the blastocyst can be destroyed at this point if it does not synthesize and release enzymes to prevent menstruation. Once again, the outer layer of cells performs this function. At this point a pregnancy is established.

After implantation occurs, the cells of the blastocyst divide and rearrange to produce three distinctive germ layers. This signifies early embryo development as tissues and organs are gradually formed. First, two cavities are formed in the inner mass of cells now called the **gastrula**. The first cavity forms the **amniotic cavity** in which the amnion will be formed to enclose and protect the embryo as it develops. The cells of the amniotic cavity in the lower portion form the outer layer of cells on the embryo called the **ectoderm**, the first germ layer. This layer produces body outercoverings - skin, nails, hair, part of the nervous system and brain.

A few days later, the second cavity forms a structure called the **yolk sac**. The yolk sac forms the inner layer of cells of the embryo called the **endoderm**. This layer produces the linings of the internal organs of the digestive system.

About 6 days later, the third germ layer forms between the ectoderm and endoderm called the **mesoderm**. Each of these germ layers gives rise to specific organs and itssues in the embryo as is outlined in the following chart.

ECTODERM	MESODERM	ENDODERM
Epidermis of skin, including Skin glands Hair and nails Lens of eye	Muscle Skeletal, cardiac, smooth	Epithelium of Pharynx Auditory tube Tonsils Thyroid Parathyroid Thymus Larynx Trachea Digestive tube and its glands Bladder Vagina Urethra and glands
Epithelium of Nasal cavities Sinuses Mouth including glands and enamel Sense organs Anal canal	Connective tissue including Cartilage Bone Blood Bone marrow Lymphoid tissue	
Nervous tissue Adrenal medulla	Epithelium of Blood vessels Lymphatics Coelomic cavities Kidney and ureters Gonads and ducts Adrenal cortex Joint cavities	

Figure 3: Structures Formed from the Three Germ Layers

Implantation and Placenta Formation

After implantation, placenta formation occurs. The **placenta** is a blood-filled structure through which nutrients and wastes exchange between the embryo and the mother.

Figure 19.3 on page 449 of your textbook illustrates the exchanges that take place.

Placenta formation is a result of mesoderm cells and outer cells of the blastocyst forming a protective layer around the embryo. This layer is called the **chorion** and has finger-like projections that increase the surface area for nutrient exchange and elimination of wastes. The finger-like projections plus the tissues in the uterus connect to form the placenta.

READ

Read the section entitled "Structures Within the Uterus" in your textbook (pp. 448 - 450).

Although the placenta contains blood vessels from both the mother's and the embryo's blood system, no mixing of blood occurs. The placenta acts as a barrier in allowing substances to enter and exit. Exchange actually takes place through the capillaries of both systems. This is illustrated on page 449 in your textbook.

The placenta is connected to the embryo by the umbilical cord which consists of one vein and two arteries. The normal procedure of gas exchange is reversed. In this situation, the vein brings oxygen to the embryo from the mother and carbon dioxide is released through the arteries.

As the embryo develops, tissues become more distinct due to differentiation of cells in the embryo. Once the bone cells begin to form and identifiable features develop whereby the embryo can be identified as to species, the embryo is called a **fetus**.

Development of the Embryo

READ

Read the section entitled "Development of the Embryo and Fetus" in your textbook (pp. 451 - 455).

Gestation refers to the period of development in the uterus. In humans, the gestation period is nine months.

Exercise 1

Complete the following questions using your lesson notes and the information from your textbook.

1. Complete the following statements by filling in the numbered blanks on the right with the correct word.

(a) ____(1)____ is the sequence of processes whereby a cell divides to form two cells having the same number of chromosomes.

(b) The process of fixing the embryo in the uterus is ____(2)____ .

(c) A ____(3)____ is a hollow ball of cells formed in early development.

(d) The tube that transports the egg from the ovary to the uterus is the ____(4)____ .

(e) A solid group of cells formed within days after fertilization is called a ____(5)____ .

(f) The ____(6)____ is a fluid-filled sac around the embryo.

(g) The outer layer of cells formed from the developing embryo is the ____(7)____ while the innermost layer is the ____(8)____ .

(h) The layer between the above two layers is the ____(9)____ .

(i) An unborn human showing bone formation around the 8th week of development is called a ____(10)____.

(j) The ____(11)____ is the structure through which the embryo is nourished in the uterus.

(k) The outer membrane of the embryo that helps form the placenta is called the ____(12)____.

(l) The process of implantation takes about ____(13)____ days.

(1) ____________________

(2) ____________________

(3) ____________________

(4) ____________________

(5) ____________________

(6) ____________________

(7) ____________________

(8) ____________________

(9) ____________________

(10) ____________________

(11) ____________________

(12) ____________________

(13) ____________________

2. The three germ layers that are formed give rise to special organs and tissues. Name the three layers and list 5 structures derived from each.

(a) ______	(b) ______	(c) ______
1. ______	1. ______	1. ______
2. ______	2. ______	2. ______
3. ______	3. ______	3. ______
4. ______	4. ______	4. ______
5. ______	5. ______	5. ______

3. Identify the month that each of these major changes occur in the embryo during pregnancy.

(a) The testes in a male fetus descend into the scrotum. __(1)__ month

(b) Eyelids form and eyes can open. __(2)__ month

(c) Pressure increases in the umbilical cord due to circulating fluids. Prevents a restricted flow of blood through umbilical cord. __(3)__ month

(d) Yolk sac produces blood cells until bones are formed. __(4)__ month.

(e) Heart first begins to beat. __(5)__ month.

(f) Fat deposits start to build up in the fetus' body. __(6)__ month.

(g) Fetus is completely formed and gestation period is complete. __(7)__ month.

(h) Fetus is recognized as a human baby. __(8)__ month.

(i) Skin is coated with vernix to protect the skin in amniotic fluid. __(9)__ month.

(j) Zygote is formed. __(10)__ month.

(1) ______

(2) ______

(3) ______

(4) ______

(5) ______

(6) ______

(7) ______

(8) ______

(9) ______

(10) ______

Please check your answers with those given on page 17.

Pregnancy and the Mother

A pregnant woman will undergo both physical and mental changes during these nine months. The physical changes become apparent as illustrated in the diagram below.

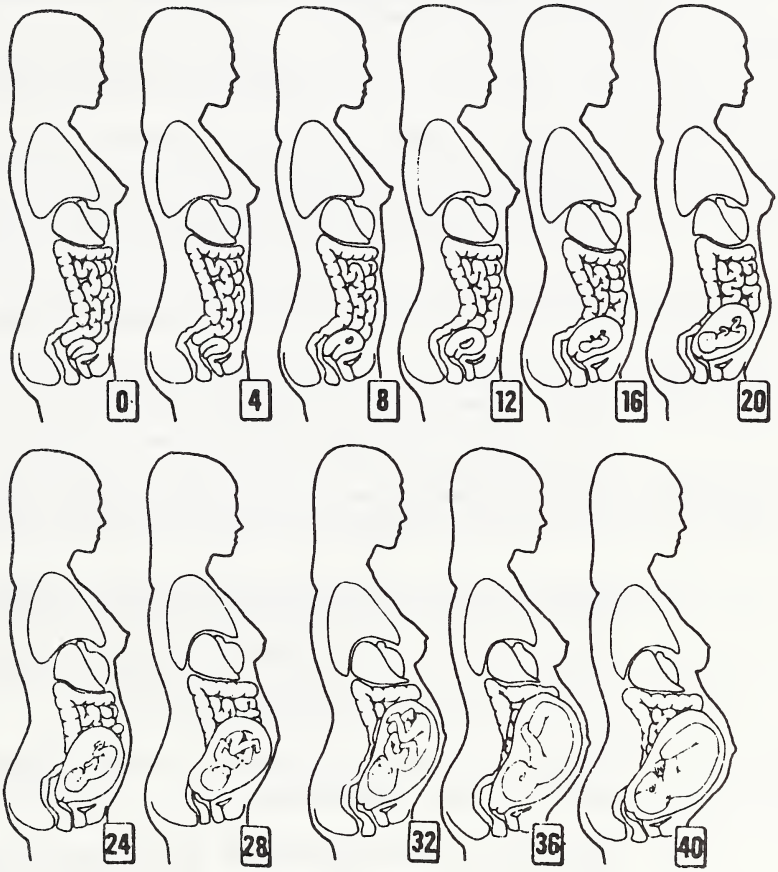


Figure 4: Changes in the Pregnant Woman

Physical changes soon appear. First **amenorrhea** or absence of menstruation occurs. However, not all women experience regular menstrual periods so this may not be a ''sure'' sign of pregnancy. After the third month, the effects of pregnancy become more visible as the abdomen swells due to expansion of the uterus. As the pregnancy progresses and the abdomen extends itself, stretch marks may appear and last until after birth. This again depends on the individual. By the fourth and fifth month, fetal life is apparent as the mother experiences ''quickening''. These sensations are similar to ''butterflies'' in the abdomen. The first sensations are faint but as time progresses they become quite strong. After the fifth month, the fetal heart beat can be monitored with a stethoscope and fetal movements such as ''kicking'' are visible from the outside.

Naturally, as the pregnancy progresses and the fetus develops, a woman will gain weight. Weight gain differs from woman to woman but the average gain is between 11.5 to 13.5 kg. A woman's shape, as illustrated in the diagram on page 7 changes as she becomes increasingly larger in the abdomen. The navel will protrude but will invert again after birth. Posture changes to accomodate the baby's weight. Leaning back to do so often results in backaches. The walk becomes more a waddling movement since the legs are spread further apart. As the pregnancy continues, hormonal levels and pressure of the fetus may cause discomfort resulting in insomnia.

The hormonal effects on the woman are manifested as follows:

1. Emotional or mood behavior - As the hormone levels are altered changes occur emotionally. In the first three months, when the pregnancy is not yet apparent, a woman may feel uncertain. Hormones are undergoing change and she is starting to gain weight. To outsiders, the obvious reason for weight gain is not always apparent and the woman may feel ''just fat''. By the second trimester or fourth month, this feeling is usually replaced as the woman accepts her pregnancy and the hormones become adjusted. Also, by this time, the reason for physical changes and weight is correctly deduced.

2. Morning sickness - Not all women experience morning sickness, however, about two-thirds do. Morning sickness usually lasts from the first missed menstrual period to about the third month. The severity of this condition varies from nausea in the morning to vomiting throughout the day. It is believed that increased levels of estrogen cause morning sickness. At times, cooking smells may trigger the nausea. Dry toast or crackers are often eaten to help subdue the effects of morning sickness.

3. Breast enlargement - The breasts enlarge to prepare for nursing or lactation. They may tingle, feel heavy, sore or painful at times. Veins become more visible and the nipples secrete a thin fluid called **colostrum** by the fourth month. The areolae pigmentation becomes darker. Increased pigmentation also becomes visible on facial areas and as a vertical line from the navel to the genitals.

4. Appetite - Naturally as the fetus develops, a woman's appetite increases. Cravings and dislikes for certain foods increase.

5. Constipation - Constipation may result due to decreased motility of the large intestine. Hemorrhoids may result. Constipation is often relieved by eating dry fruits or bran.

6. Heartburn - The burning sensation of heartburn due to relaxation of the esophagus sphincter becomes a reality. The diet of the pregnant woman would have to be altered to prevent this discomfort.

The fetus itself exerts changes. For example, as the pressure of the fetus increases on the bladder urination becomes more frequent. Usually this begins in the third month and lasts until the end of pregnancy. Internal movements, as discussed previously, occur. Another obvious change due to fetal pressure on the main leg veins is the appearance of varicose veins. These veins dilate as the pressure to return blood to the heart increases. This physical condition can be relieved by simply resting with the feet slightly elevated. The wearing of support hose also helps.

Hormones of Pregnancy

A pregnancy cannot be maintained without the interaction of certain hormones. The **corpus luteum** normally shed during menstruation is maintained. It continues to secrete estrogens and progesterone for about ten weeks after fertilization. Together these hormones maintain the lining of the uterus and produce changes in mammary glands to stimulate milk production. However, as the pregnancy progresses, higher levels of estrogen and progesterone are needed to maintain it and produce physical changes in the woman's body.

The placenta now functions in hormone development and control. Very early, **human chorionic gonadotropin (HCG)** is secreted by the chorion of the placenta. HCG sustains hormone production of the corpus luteum. This is vital as progesterone secretions are needed to ensure continuance of implantation of the fetus in the uterus. At about the fourth month, the placenta now maintains pregnancy by producing the needed estrogen and progesterone. HCG levels decrease as the corpus luteum is no longer the functioning hormone producer. Evidence indicates that the placenta also produces a **placental luteotrophic releasing factor (PLRF)**. This hormone stimulates secretion of HCG.

A second hormone produced by the chorion is **human chorionic somatomammotropin (HCS)**. Production of HCS begins at the same time as HCG but the HCS secretion amount increases as the placenta mass increases. At about the eighth month, this secretion stabilizes. HCS functions in breast tissue development, and in fetal growth. This hormone causes glucose utilization of the mother to be decreased and diverted to the fetus for growth. The mother's metabolism then relies on energy derived from fat deposits.

Prior to the onset of labor, the placenta and ovaries produce **relaxin**. Relaxin causes ligaments between the pelvic bones to loosen. This provides a flexible passageway for the birth of the baby.

The diagram below summarizes hormones involved in pregnancy.

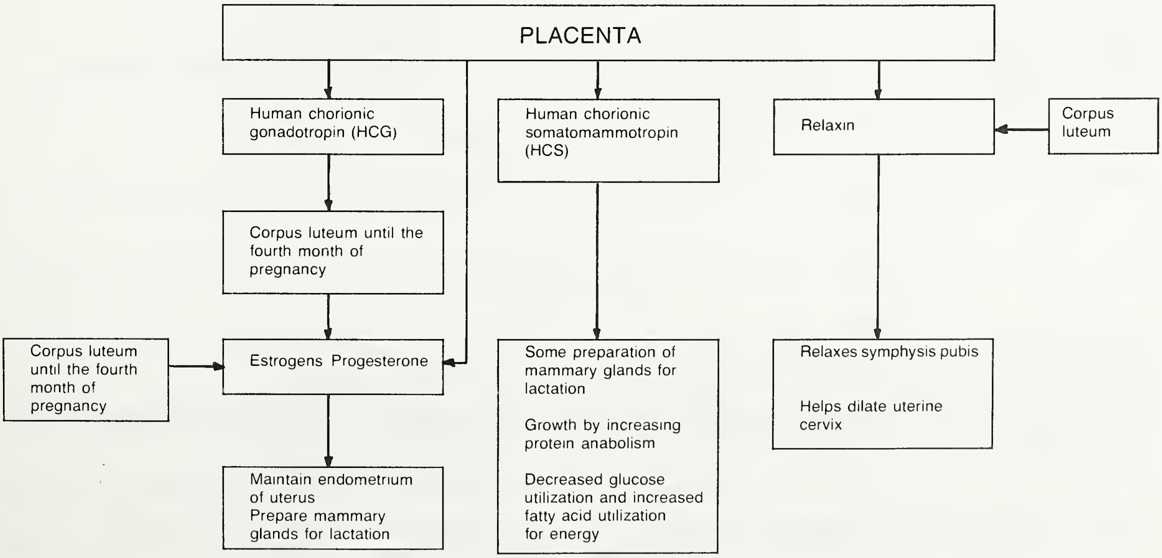

PLACENTA
Human chorionic gonadotropin (HCG)
Human chorionic somatomammotropin (HCS)
Relaxin
Corpus luteum
Corpus luteum until the fourth month of pregnancy
Corpus luteum until the fourth month of pregnancy
Estrogens Progesterone
Some preparation of mammary glands for lactation
Growth by increasing protein anabolism
Decreased glucose utilization and increased fatty acid utilization for energy
Relaxes symphysis pubis
Helps dilate uterine cervix
Maintain endometrium of uterus
Prepare mammary glands for lactation

Figure 5: Hormonal Control During Pregnancy

Exercise 2

Complete the following questions using your lesson notes and the information given in your textbook.

1. Complete the following statements by filling in the numbered blank on the right with the correct word.

   (a) ____(1)____ is the absence of menstruation.

   (b) The first sensation of life in the mother is referred to as ____(2)____ .

   (c) As fetal development continues and the mother gains weight ____(3)____ may appear as a result of physical changes.

   (d) The average weight gain during pregnancy is between ____(4)____ to ____(5)____ kg.

   (e) Morning sickness is believed to be caused by high levels of ____(6)____ .

   (f) ____(7)____ , a thin fluid, is secreted by the nipples as the breasts prepare for ____(8)____ .

   (g) Two effects of the fetus exerting pressure on the mother are apparent in the mother experiencing frequent ____(9)____ and ____(10)____ development.

   (1) ____________________

   (2) ____________________

   (3) ____________________

   (4) ____________________

   (5) ____________________

   (6) ____________________

   (7) ____________________

   (8) ____________________

   (9) ____________________

   (10) ____________________

2. Name the four structures that secrete hormones needed to sustain a pregnancy.

   (a) ____

   (b) ____

   (c) ____

   (d) ____

3. Name the hormones produced by the above structures and describe the function of each.

   (a) ____

   ____

   ____

(b) ____

____

____

(c) ____

____

____

(d) ____

____

____

Please check your answers with those given on pages 17 and 18.

Birth and Labor

Upon completion of the gestation period, parturition or birth takes place. This is accompanied by the process of labor. Labor is probably initiated by hormonal control.

Relaxin is produced by the placenta and ovaries prior to labor. A flexible passageway for the birth is prepared. The progesterone level maintained by the placenta decreases and muscular contractions of the wall of the uterus begin as estrogen exerts its effects. Two other major hormones exert their effects as well -- **prostaglandins** and **oxytocin**. Prostaglandins produce vigorous contractions of the uterus called labor pains. Oxytocin secreted by the posterior pituitary gland also stimulates the contractions of the uterus. The cervix begins to dilate due to relaxin.

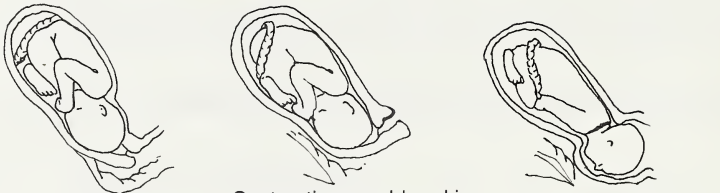
The three stages of labor begin. They are:

1. the opening of the birth canal by dilation due to relaxin. The mucus plug in the cervix is expelled with a minute loss of blood. Regular contractions occur, the amniotic sac ruptures and the cervix becomes dilated to 10 cm. If the amniotic sac does not rupture on its own, it can cause increased discomfort as it presses down on the bladder. It is then broken artificially.

2. the birth of the baby which begins at the time of complete cervix opening to delivery.

3. the delivery of the placenta or afterbirth due to strong contractions of the uterus. Blood vessels are also constricted by these contractions which helps minimize hemorrhaging.

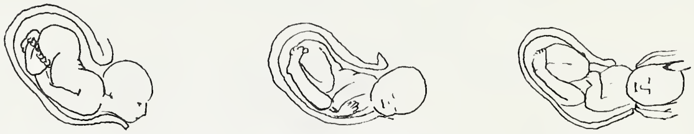
The diagram below illustrates these stages of labor.



Lightening

Contractions and breaking of the bag of waters

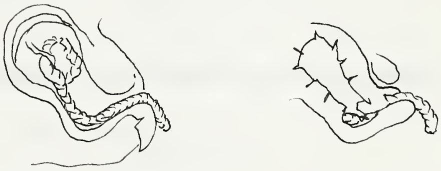
Dilation of the cervix



Visible head. Beginning of birth

Delivering the head

Rotation



The afterbirth (placenta)

Expelling afterbirth

Figure 6: Stages of Labor and Birth

The umbilical cord that is still attached to the baby must be tied.

Variations in Birth and Labor

The length of labor for each woman varies and depends on the individual's physical structure and hormone balance. Labor may be very quick, a few hours long, or up to 16 hours or longer. It can progress slowly if the cervix is not completely dilated, if the baby hasn't descended into the pelvic area, if contractions are not strong enough, or if the baby is too large for the birth canal. Often during the delivery process an **episiotomy** is performed. A doctor cuts the vaginal opening to prevent tearing of tissues. After delivery, the cut is then stitched together.

Babies are not always in the proper postion for birth. A breech birth is one in which the fetus moves into the birth canal feet first. Labor will progress normally unless the mother has a small pelvis or the baby has a large head. A lengthy delivery could result in oxygen deprivation if the head squeezes the umbilical cord. A **breech baby** is delivered in three stages: first the legs and breech emerge, then the shoulders and finally the head. Forceps may be used to ease the head out of the birth canal.

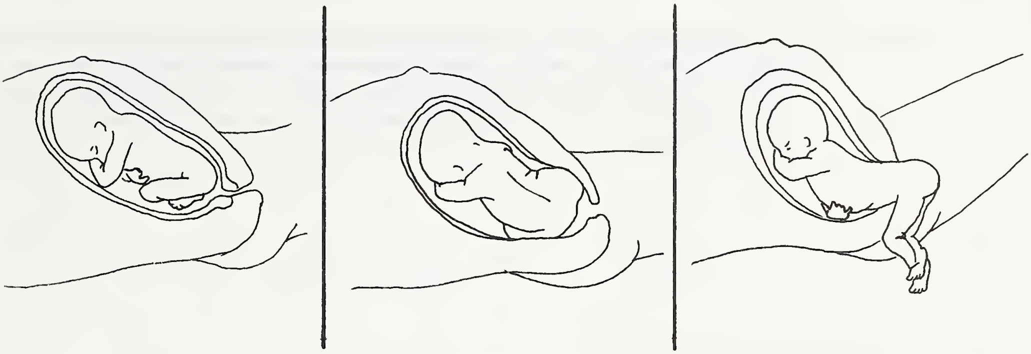


Figure 7: Breech Birth

To avoid complications as in breech births or fetal distress a **Caesarean section** delivery may take place.. A Caesarean section is an opening made in the mother's abdomen and uterus to remove the baby and placenta. The abdominal wall is carefully closed and the mother takes a few days longer to recover than in a normal birth. The mother can still nurse the baby if she wishes. Caesareans are performed if the doctor feels the mother's life or the baby's may be endangered by a vaginal birth.

Often a woman may experience false labor before true labor sets in. The following chart indicates the differences between the two types of labor.

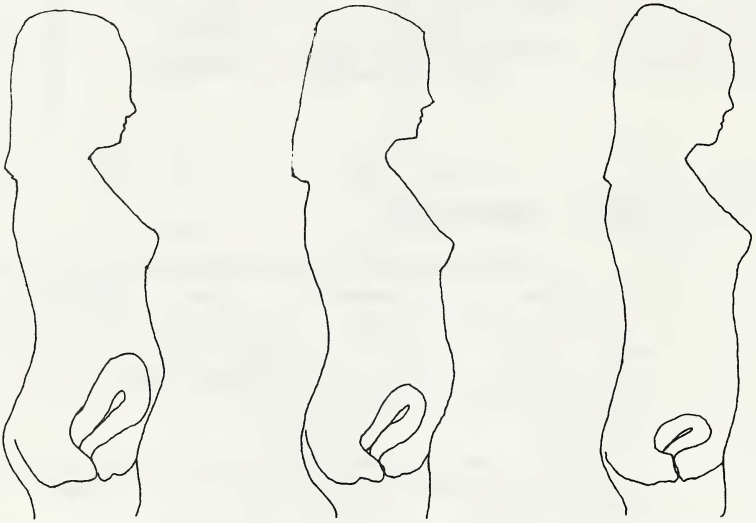
True Labor	False Labor
1. A ''bloody show'' or spotting accompanied by cramps or pains.	1. No ''bloody show'' or cramps.
2. Contractions increase and become stronger.	2. Irregular contractions and not lasting nor strong.
3. Contractions increase and become stronger with walking or position change.	3. Contractions may stop if walking or position change.

Post Natal Care

Following the birth of the baby, **lochia**, or a bloody substance leaks from the vagina of the mother as the uterus lining and placenta break down. This condition lasts for about ten days. The breast which produced colostrum up until now will produce milk after a few days. The breasts may swell and become painful. The mother may also experience constipation or difficulty in urinating. Often the lack of muscle tone in the pelvic area may cause involuntary urinating while laughing or coughing. These muscles can be toned up by special exercises.

Changes in the hormonal balance may cause temporary depression or moodiness. Menstruation will commence in about 6 to 10 weeks if the mother is not nursing. If nursing, menstrual periods may be delayed for a greater period.

Changes also occur in the size of the uterus. After delivery, the uterus weighs about 1 kg. By about the 6th week, through the process of **involution**, the uterus returns to normal size and weight. Contractions produced as a result of nursing also help to decrease the uterus size, usually much faster. The diagram below illustrates the change of uterus size over a six week period.



After birth

1 week after birth

6 weeks after birth

Figure 8: Involution of the uterus

READ

Read the sections dealing with functions of the placenta, growth differences in the sexes and nutrition. (pp. 458 - 461)

Infant Nutrition: Breast Feeding and Bottle Feeding

After birth, the parents have the choice to breast feed or bottle feed their baby. The choice to breast feed or nurse is increasing steadily. This is the safest and most natural method of infant nutrition. However, it is not always possible or convenient for a mother to nurse her baby. In this case, bottle feeding of formula milk is done.

Both breast feeding and bottle feeding have advantages and disadvantages.

Breast Feeding	Bottle Feeding
1. Establishment of early contact between mother and infant (bonding).	1. Both parents can participate in the feeding.
2. Infant can better control intake of milk.	2. Infant can overfeed.

3. Fats, iron, and amino acids in human milk are more easily metabolized as compared to cow's milk. Mother's milk also contains lower sodium content better suited to an infant's needs.	3. Milk intake can be measured.
4. Provides antibodies for respiratory infections and other ailments.	4. Mother is independent of the milk supply.
5. Less chance of an allergy to mother's milk.	5. Mother's eating habits and medication do not affect the infant.
6. The sucking action promotes development of jaws, facial muscles and teeth.	6. Bottles, equipment, and formula can be expense.
7. Milk is immediately available - at the correct temperature and sterile.	
8. Breast milk is cheaper.	
9. Milk intake cannot be measured.	
10. Mother's health and emotional state affect milk supply.	
11. Some drugs can be passed to the baby via the mother.	
12. Fathers participate less in feeding.	

Exercise 3

Complete the following questions using your lesson notes and the information given in your textbook.

1. List the three major hormones involved in labor and explain their function.

(a) ____

____

(b) ____

____

(c) ____

____

2. Briefly summarize the three stages of labor.

(a) ____

(b) ____

(c) ____

3. Complete the following statements by filling in the blanks.

(a) ______________ refers to the process of birth.

(b) The ______________ level decreases as the ______________ level increases to produce muscular contractions of the uterus wall.

(c) The cervix is fully dilated at ________ cm.

(d) An ______________ is often performed to prevent vaginal tissue from tearing.

(e) In a ____________ ______________ the feet move into the birth canal first.

(f) If complications arise endangering the life of the fetus or mother during birth and the labor process, a ______________ ______________ may be performed.

(g) Following birth, ______________ or a bloody discharge is evident as the uterus lining breaks down.

(h) The process whereby the uterus returns to normal size is called ______________ .

(i) The most natural method of infant nutrition is ________________ .

Please check your answers with those given on page 18.

ANSWERS TO THE KEYED EXERCISES

Exercise 1, pp. 5 - 6.

1. Complete the statements.

(1) **mitosis**
(2) **implantation**
(3) **blastocyst**
(4) **oviduct**
(5) **morula**
(6) **amnion**
(7) **ectoderm**
(8) **endoderm**
(9) **mesoderm**
(10) **fetus**
(11) **placenta**
(12) **chorion**
(13) **10 days**

2. The three germ layers are:

(a) **ectoderm** (b) **endoderm** (c) **mesoderm**

See Figure 3, page 3, of the lesson notes for structures and organs derived from each layer.

3. The months of the major developments are:

(1) **8th**
(2) **6th**
(3) **4th**
(4) **2nd**
(5) **1st**
(6) **8th**
(7) **9th**
(8) **3rd**
(9) **7th**
(10) **1st**

Exercise 2, pp. 10 - 11.

1. Complete the statements.

(1) **amenorrhea**
(2) **quickening**
(3) **stretch marks**
(4) **11.5 kg**
(5) **13.5 kg**
(6) **estrogen**
(7) **colostrum**
(8) **lactation**
(9) **urination**
(10) **varicose veins**

2. Structures that secrete hormones to sustain a pregnancy are

(a) **corpus luteum**
(b) **placenta**
(c) **chorion**
(d) **ovaries**

3. (a) **Corpus luteum produces estrogen and progesterone. These hormones maintain the lining of the uterus and initiate milk production.**

   (b) **Placenta produces HCG to maintain the corpus luteum secretions, produces estrogen and progesterone to maintain the pregnancy and produces HCS to prepare mammary glands for lactation.**

   (c) **Chorion produces HCS to prepare mammary glands for lactation, promotes glucose utilization for fetal development and produces fatty acids used for mother's growth and energy needs.**

   (d) **Placenta and ovaries produce relaxin which helps loosen pelvic bones and dilate the cervix.**

Exercise 3, pp. 15 - 16.

1. Three major hormones involved in labor are:

   (a) **relaxin - loosens pelvic bone structure and dilates the cervix**

   (b) **prostaglandins - produces vigorous contractions of the uterus - labor pains**

   (c) **oxytocin - stimulates contractions of the uterus**

2. The three stages of labor are:

   (a) **opening of birth canal by dilation**

   (b) **birth of baby through the canal**

   (c) **delivery of the placenta or afterbirth**

3. Complete the statements.

   (a) **Parturition**
   (b) **progesterone, estrogen**
   (c) **10**
   (d) **episiotomy**
   (e) **breech birth**
   (f) **Caesarean section**
   (g) **lochia**
   (h) **involution**
   (i) **breast feeding**

EXERCISES TO BE SENT IN FOR CORRECTION

Part One: Multiple Choice

For each of the following questions choose the best answer and write the appropriate letter in the blank provided.

______ 1. The temporary structure that provides the embryo with blood cells is the

- (a) yolk sac.
- (b) amnion.
- (c) umbilical cord.
- (d) blastocyst.

______ 2. The total period of time that the fetus is in the uterus is called

- (a) implantation.
- (b) gastrulation.
- (c) parturition.
- (d) gestation.

______ 3. A solid mass of cells that forms after the sperm and ovum unite is the

- (a) blastocyst.
- (b) morula.
- (c) gastrula.
- (d) blastocoel.

______ 4. The cells of the amniotic cavity form the outer layer of cells on the embryo called the

- (a) endoderm.
- (b) ectoderm.
- (c) coelom.
- (d) mesoderm.

______ 5. The germ layer responsible for formation of bone and cartilage structure is the

- (a) ectoderm.
- (b) mesoderm.
- (c) endoderm.
- (d) both (a) and (c).

______ 6. Which of the following tissues is not a result of the ectoderm formation?

- (a) lining of the nasal cavities
- (b) epidermis of the skin
- (c) epithelium of blood vessels
- (d) nervous tissue

_____ 7. The structure that connects the baby with the placenta is the

(a) amnion.
(b) chorion.
(c) yolk sac.
(d) umbilical cord.

_____ 8. Which is not a function of the placenta?

(a) functions in nutrient and oxygen exchange
(b) allows wastes and CO_2 to pass from mother to fetus
(c) prevents the mother from rejecting the fetus
(d) acts as a barrier to bacteria

_____ 9. Which is not a shock the baby experiences after birth?

(a) moving from a wet environment to a dry one
(b) starting its own excretory process
(c) moving limbs - arms and legs
(d) breathing on its own and digesting its own food

_____ 10. The term that best describes the first fetal movements in a pregnancy is

(a) ''lightening''.
(b) ''quickening''.
(c) ''kicking''.
(d) none of the above.

_____ 11. The hormone often referred to as the ''pregnancy hormone'' that maintains the lining of the uterus and produces changes in the mammary glands is

(a) progesterone.
(b) follicle stimulating hormone.
(c) prostaglandin.
(d) corpus luteum.

_____ 12. ________ causes the ligaments between the pelvic bones to loosen.

(a) prostaglandins
(b) HCS
(c) HCG
(d) relaxin

_____ 13. The hormone that produces the strongest contractions of the uterus wall is

(a) estrogen.
(b) prostaglandins.
(c) oxytocin.
(d) progesterone.

______ 14. The amniotic sac rupturing occurs in the

(a) 1st stage of labor.
(b) 2nd stage of labor.
(c) 3rd stage of labor.
(d) onset of labor.

______ 15. Which of the following is not necessarily a reason for Caesarian section delivery?

(a) a small birth canal or pelvis
(b) fetal distress
(c) breech birth
(d) previous uterine injury

Part Two: True or False Questions

Indicate whether the following statements are True or False by circling the correct letter at the beginning of each statement.

T F 1. After implantation, the blastocyst must release enzymes to prevent menstruation.

T F 2. The first cavity formed in the blastocyst forms the yolk sac.

T F 3. The ectoderm produces the linings of the internal organs of the digestive system.

T F 4. The finger-like projections of the chorion plus tissues in the uterus connect to form the placenta.

T F 5. In the umbilical cord, the vein releases carbon dioxide from the embryo to the mother.

T F 6. A sure sign of pregnancy is amenorrhea.

T F 7. As a pregnancy is initiated hormonal changes can cause emotional changes in a woman.

T F 8. Involution of the uterus can be speeded up by the actions of breast feeding.

T F 9. Mother's milk and formula are equally as nutritious and easily digested.

T F 10. Labor is probably initiated by hormonal changes.

T F 11. Oxytocin causes the cervix to dilate.

T F 12. Fertilization of the ovum by the sperm occurs in the first third of the uterus.

T F 13. Fraternal twins develop from a single ovum fertilized by a single sperm.

T F 14. The term fetus is used when the fetal heart starts to beat.

T F 15. The umbilical cord carries two veins and one artery.

T F 16. Drugs and alcohol can cross the placenta barrier and enter the fetal blood.

T F 17. In true labor contractions may stop if the mother exercises by walking.

T F 18. Nausea or "morning sickness" is believed to be a result of increased levels of estrogen.

T F 19. Prior to labor, the placenta produces prostaglandins to prepare the birth canal for the birth of the baby.

T F 20. The mucus plug in the cervix is expelled after the amniotic sac ruptures.

Part Three: Short Answer Questions

1. Explain the difference in the formation of fraternal and identical twins.

____

____

____

____

2. Explain the importance of a proper hormone balance or control in maintaining a pregnancy.

____

____

____

____

____

3. List 5 nutritional and medical benefits of nursing over bottle feeding.

(a) ______________________________

(b) ______________________________

(c) ______________________________

(d) ______________________________

(e) ______________________________

4. Outline the importance or the functions of the placenta.

5. Describe the changes that occur in a woman following childbirth.

Submit pages 19 to 23 for correction.

END OF LESSON 16

LESSON RECORD FORM

3230 Biology 30
Revised 03/89

FOR STUDENT USE ONLY

Date Lesson Submitted ____________________

Time Spent on Lesson ____________________

(If label is missing
or incorrect)

File Number ____________________

Lesson Number __________

FOR SCHOOL USE ONLY

Assigned
Teacher: __________

Lesson Grading: ________

Additional Grading
E/R/P Code: ________

Mark: __________

Graded by: __________

Assignment Code: ______

Date Lesson Received:

____

Lesson Recorded ______

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MAILING INSTRUCTIONS FOR CORRESPONDENCE LESSONS

1. BEFORE MAILING YOUR LESSONS, PLEASE SEE THAT:

(1) All pages are numbered and in order, and no paper clips or staples are used.
(2) All exercises are completed. If not, explain why.
(3) Your work has been re-read to ensure accuracy in spelling and lesson details.
(4) The Lesson Record Form is filled out and the correct lesson label is attached.
(5) This mailing sheet is placed on the lesson.

2. POSTAGE REGULATIONS

Do **not** enclose letters with lessons.

Send all letters in a separate envelope.

3. POSTAGE RATES

First Class

Take your lesson to the Post Office and have it weighed. Attach sufficient postage and a **green first-class sticker to the front of the envelope, and seal the envelope. Correspondence lessons will travel faster if first-class postage is used.**

Try to mail each lesson as soon as it has been completed.

When you register for correspondence courses, you are expected to send lessons for correction regularly. Avoid sending more than two or three lessons in one subject at the same time.

OBJECTIVES

At the end of Lesson 17, the student should be able to:

1. **Describe** the stages of plant development.
2. **Differentiate** between Bryophyta (non-vascular) and Tracheophyta (vascular).
3. **Describe** the Gymnospermae and Angiospermae plant classes.
4. **Compare** the monocot and dicot plant structure.
5. **Recognize** the parts of the root and shoot structures of a plant.
6. **Understand** the function of a plant bud.
7. **Label** the basic parts of a flower, including the parts involved in reproduction and understand their function.
8. **Describe** the process of pollination and fertilization.
9. **Outline** the seedling development of the monocot and the dicot, including the roles of water, temperature and oxygen in development.
10. **Discuss** the external and internal factors affecting the growth responses of the plant.

PLANT ANATOMY AND PHYSIOLOGY

Introduction

The existence of green plants on the earth's surface and in the oceans makes possible the existence of man. Green plants supply man with food and oxygen, and are a link in the continuous cycle of carbon and oxygen. In the past, plants died to form the fossil fuels that we are so dependent upon today. Plants are also a renewable resource, providing us with shelter, clothing, tools and an aesthetically pleasing environment.

To ensure human survival, natural plant species and their habitats must be preserved. Production of agricultural plants must also be increased as the world population increases. Human beings cannot exist independently of plants.

This lesson will examine plants, their structure, and stages of development from the seed to the mature plant.

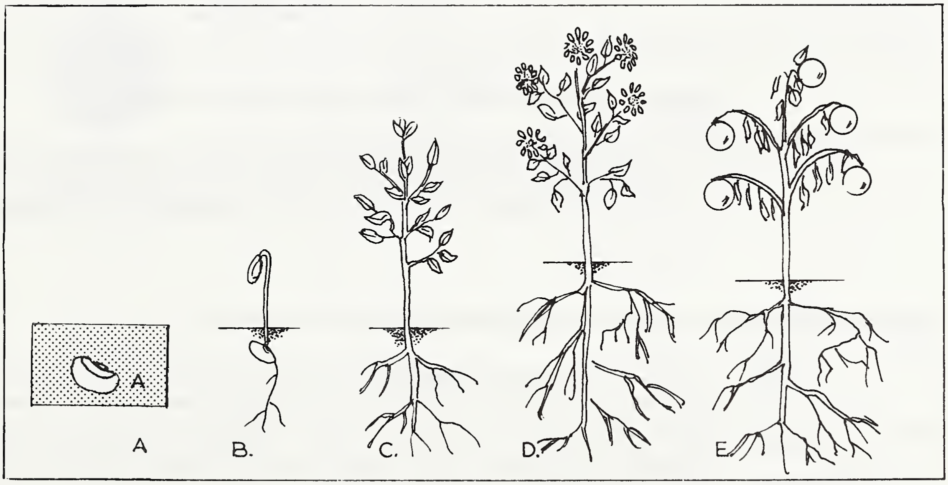


Figure 1: Plant development stages
A. seed; B. seedling; C. vegetative stage; D. flowering and E. fruiting stage.

Classification

The following diagram is the suspected evolutionary relationship of plants.

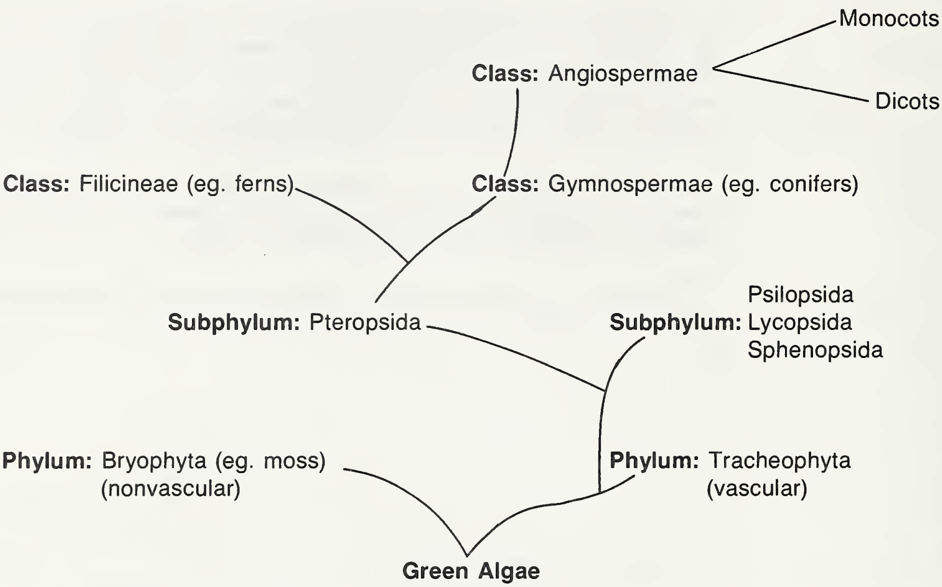
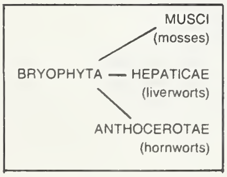

Monocots
Class: Angiospermae
Dicots
Class: Filicineae (eg. ferns)
Class: Gymnospermae (eg. conifers)
Psilopsida
Subphylum: Pteropsida
Subphylum: Lycopsida
Sphenopsida
Phylum: Bryophyta (eg. moss) (nonvascular)
Phylum: Tracheophyta (vascular)
Green Algae

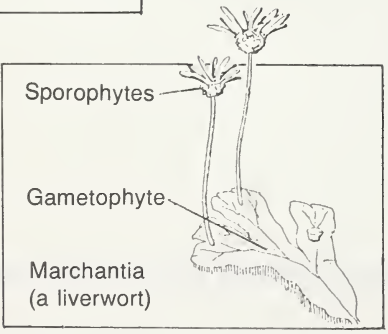
Figure 2: Possible Evolutionary Relationship of Plants

Advanced plants are believed to have evolved from green, fresh-water algae. The advanced plants are broken down into two phyla: the bryophytes and tracheophytes. This differentiation is based on their structural differences pertaining to vascular tissue.

Bryophyta (Nonvascular plants: mosses, liverworts and hornworts)

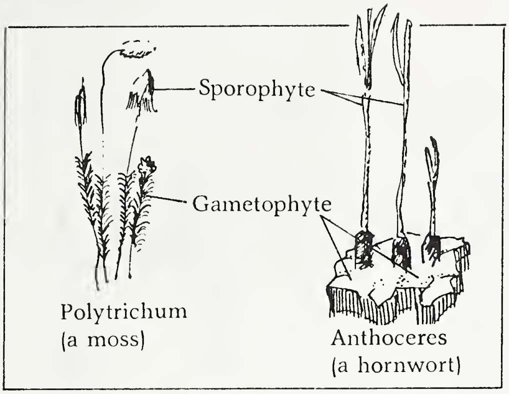


Bryophytes are small plants that have either a flat body that lies on the ground or a central stalk that bears leaves. They attach themselves to soil, rock and other plants by rhizoids and are important soil formers and builders. They gradually wear down large rock into smaller fragments by acid secretions. A common example of a bryophyte is the moss plant.



Bryophytes are found in all parts of the world and are characterized by the following features:

1. lack of vascular tissue. These are food and water conducting tubes allowing for transport. Vascular tissue strengthens the true stems found in more advanced plants.
2. have no true roots, leaves, or stems but only simple organs to carry out the functions of these structures. For example, Bryophytes have rhizoids for attachment of the plant to a substrate instead of a root system.



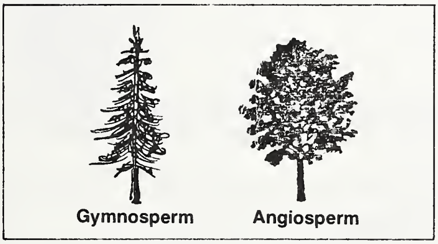
3. grow in damp or aquatic habitats.

4. exhibit alternation of generations. Gametophyte generation is dominant over the sporophyte.*

* In their life cycle, Bryophytes have two alternating generations. One generation, called the **gametophyte,** produces the sperm and eggs, or gametes. The gametophyte alternates with the sporophyte generation. The sporophyte produces spores.

Tracheophyta (Vascular Plants)

- **Tracheophyta**
  - **Psilopsida**
  - **Lycopsida**
  - **Sphenopsida**
  - **Pteropsida**
    - **Filicineae**
    - **Gymnosperm**
    - **Angiosperm**



Tracheophytes, the more advanced plants, are more diverse and better suited to their environments because of the following characteristics:

1. plants contain vascular tissue. This allows for growth in height and distribution of food, minerals, and water to the cells.

2. body consists of three distinct parts: stems, roots, and leaves.

3. the sporophyte generation becomes dominant over the gametophyte.

In this phylum, we will concentrate on the most advanced and familiar classes: the gymnosperms and angiosperms.

Exercise 1

1. Complete each of the following statements by filling in the numbered blank on the right.

(a) The dominant generation in the bryophytes is the ____(1)____ .

(b) Plants can be divided into two broad categories, ____(2)____ and ____(3)____ , depending on the presence or absence of conducting tissue.

(c) The two classes of advanced plants are ____(4)____ and ____(5)____ .

(d) All plants show an alternation of generations which consists of a ____(6)____ generation and a ____(7)____ generation.

(1) ____________

(2) ____________

(3) ____________

(4) ____________

(5) ____________

(6) ____________

(7) ____________

(e) Bryophytes consist of three major groups: ____(8)____ , ____(9)____ , and ____(10)____ .

(f) The body of tracheophytes consists of three parts: ____(11)____ , ____(12)____ , and ____(13)____ .

(g) Bryophytes lack roots but have ____(14)____ for attachment to substrates.

(h) The four major subphyla of the phylum Tracheophyta are ____(15)____ , ____(16)____ , ____(17)____ , and ____(18)____ .

(8) ____________________

(9) ____________________

(10) ____________________

(11) ____________________

(12) ____________________

(13) ____________________

(14) ____________________

(15) ____________________

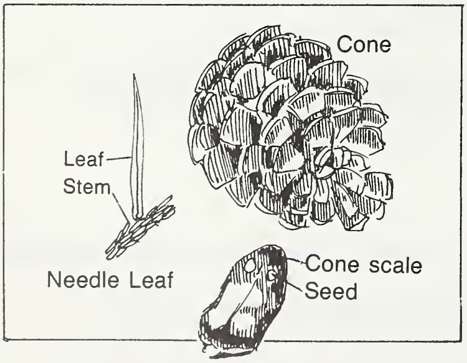
(16) ____________________

(17) ____________________

(18) ____________________

Please check your work with the answers given on page 16.

Gymnospermae

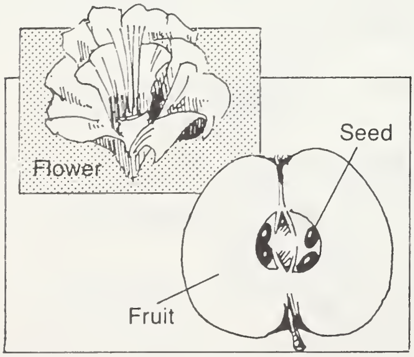


Gymnosperms are more ancient than the flowering plants (angiosperms) and flourished for some 200 million years.

Alberta has a wide variety of conifers that can withstand the difficult growing conditions. The leaves are modified in a needle shape. This shape and the thick waxy cuticle or covering help to reduce water loss and protect the leaf better than the thin flat leaf shape found amongst deciduous plants. The seeds of gymnosperms are exposed in cone scales.

Generally, these plants are woody, being either trees, shrubs, or vines. Common examples include plants such as pine, spruce, fir, hemlock, juniper and cypress. Less familiar plants of this class are the palm-like cycads and the maidenhair tree or ginko.

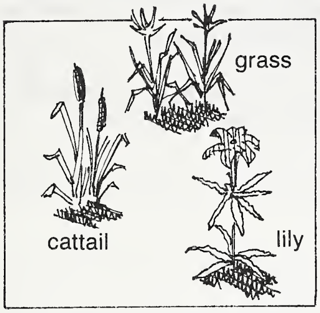
Angiospermae

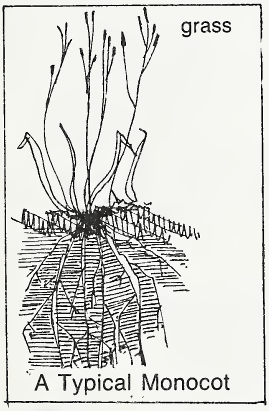


Angiosperms are the flowering plants and are often considered to be the most highly developed seed plants. They differ from gymnosperms in having ovules contained within a closed cavity. The seeds of this group are enclosed in various types of capsules — a grain, nut, legume, or fruit.

The angiosperms are divided into two subclasses, the **Monocotyledonae** and the **Dicotyledonae**. Both groups have distinctive characteristics.

Monocotyledonae (Monocots)

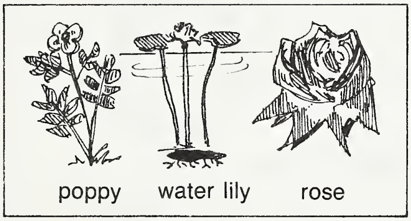


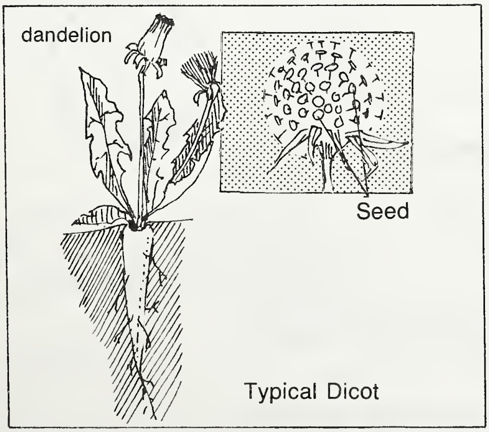


You are probably familiar with many of the monocots; corn, grass, wheat, onions, tulips, daffodils, and cattails. These plants share the following common characteristics:

1. long, sword-shaped leaves with parallel veins. There is no branching pattern to the veins.
2. flower parts - petal, sepals, stamens, and stigma lobes are in threes or multiples of three.
3. narrow stems without woody tissues because the cambium of the stems which causes growth in diameter is missing or becomes inactive.
4. conducting tissue of the stem, xylem, and phloem are scattered throughout the pith. There is no definite pattern.
5. seed has one cotyledon (embryo leaf) in which little food is stored. The majority of food is stored in the endosperm, a separate starchy area which surrounds the embryo and cotyledon.
6. possess a fibrous root system which branches out to form very fine roots.

Dicotyledonae (Dicots)





The majority of angiosperms are dicots. They include such well known plants as beans, peas, radishes, cauliflower, cabbage, strawberries, raspberries, roses, dogwoods, poplars, birches, willows, dandelions, pansies, many familiar flowers, herbs, shrubs, and trees. Characteristics pertaining to this group are:

1. leaves with netted venation. The netted pattern resembles the branching of a deciduous tree where a main branch will branch and rebranch.
2. flower parts - petals, sepals, stamens and stigma lobes are in fours or fives or multiples of four or five. For example, the rose has five petals and 5 sepals.
3. vascular bundles are in a ring. The xylem (water conducting tissue) and phloem (nutrient conducting tissue) are separated by the cambium which forms a continuous ring within the stem.
4. an increase in the diameter of the stem is possible because the cambium cells are continuously dividing to form new xylem on the inside and phloem on the outside.

5. seeds of dicots have food stored in two cotyledons. These cotyledons become the first seed leaves of the seedling. They provide nourishment to the seedling from stored food and photosynthesis.

6. possess a tap root system in which one large root is formed with smaller roots projecting from it.

The following diagrams summarize the differences which distinguish monocots from dicots.

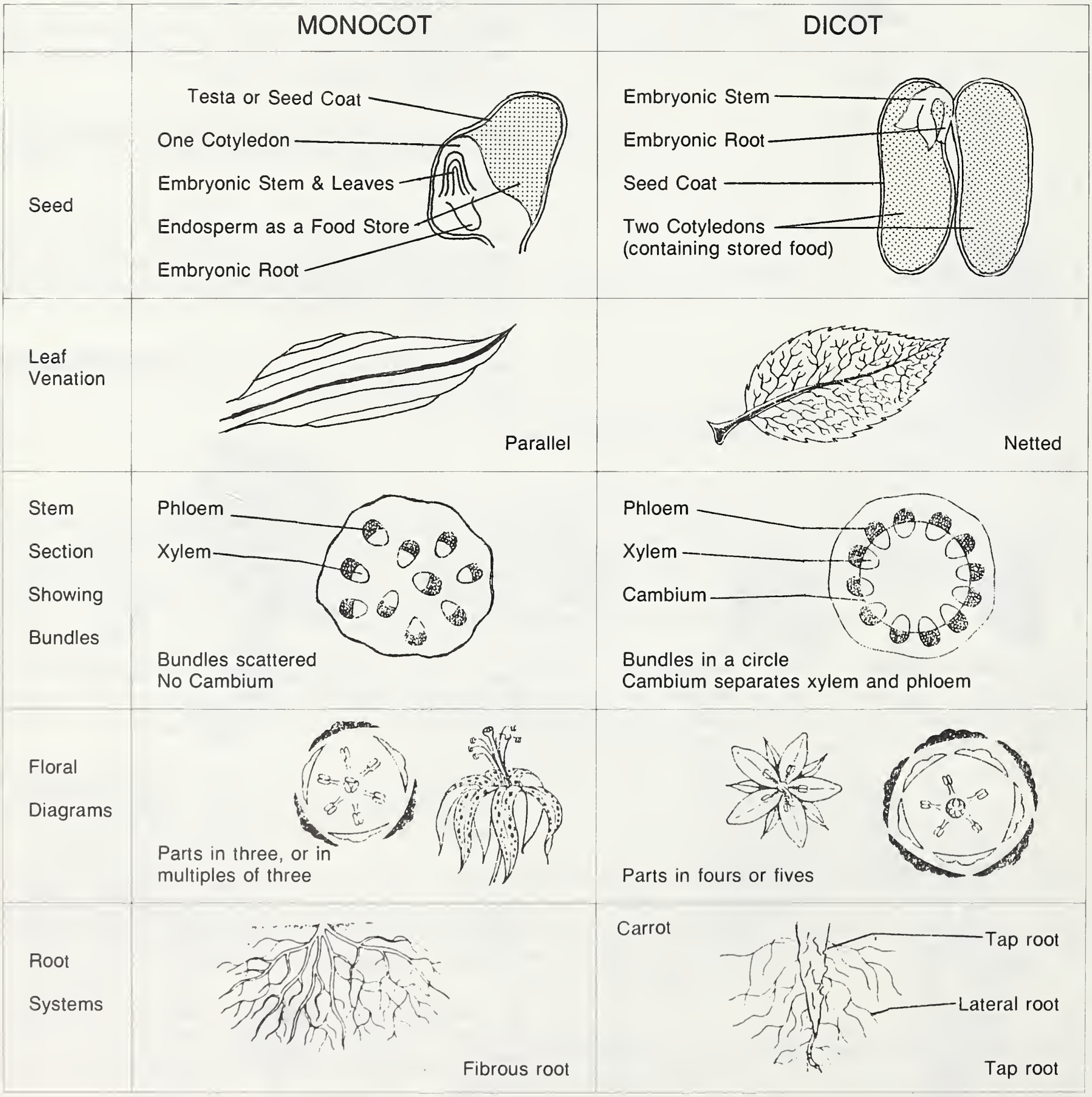


Figure 3: Comparison of Monocot and Dicot Plant Structures

Exercise 2

1. Complete each of the following statements by filling in the numbered blank on the right.

(a) The dominant generation in the tracheophytes is the ___(1)___ .

(b) The two vascular tissues in the tracheophytes are ___(2)___ and ___(3)___ .

(c) Three examples of Angiosperms are ___(4)___ , ___(5)___ , and ___(6)___ .

(d) The seed plants include the ___(7)___ and the ___(8)___ .

(e) Five examples of conifers are ___(9)___ , ___(10)___ , ___(11)___ , ___(12)___ and ___(13)___ .

(f) Two features that distinguish conifers from other plants are ___(14)___ and ___(15)___ .

(1) ____________________
(2) ____________________
(3) ____________________
(4) ____________________
(5) ____________________
(6) ____________________
(7) ____________________
(8) ____________________
(9) ____________________
(10) ____________________
(11) ____________________
(12) ____________________
(13) ____________________
(14) ____________________
(15) ____________________

2. What are the criteria for distinction between monocots and dicots?

____

____

____

Please check your work with the answers given on page 16.

Plant Development

As the monocot and dicot plants develop they can be divided into two distinct sections as is shown in the following diagrams of these plants in the vegetative stage.

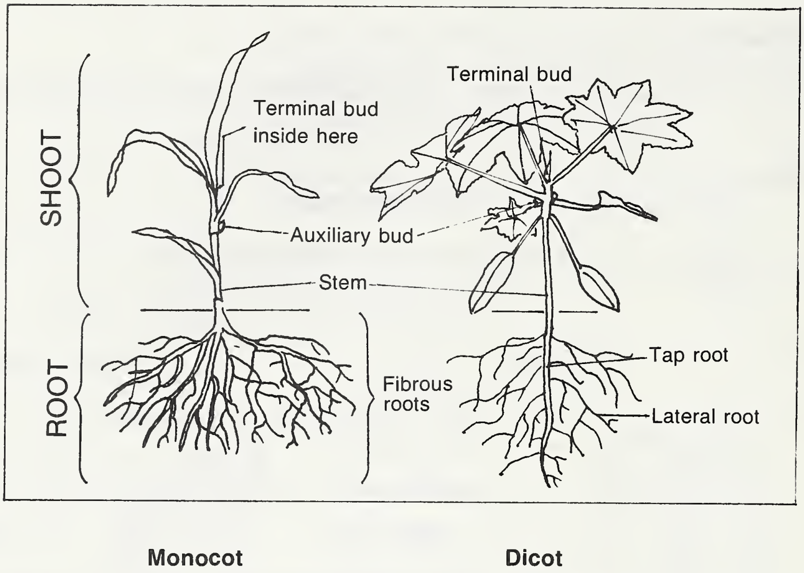
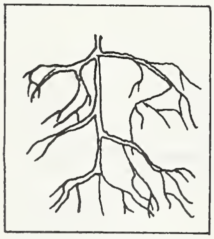
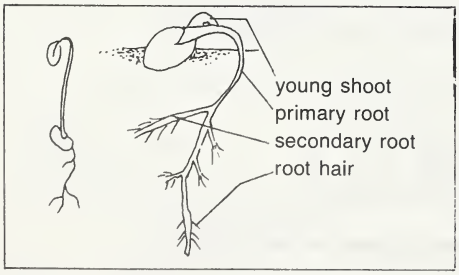


Figure 4: Vegetative stages of Monocots and Dicots illustrating root and shoot structure.

The Plant Root



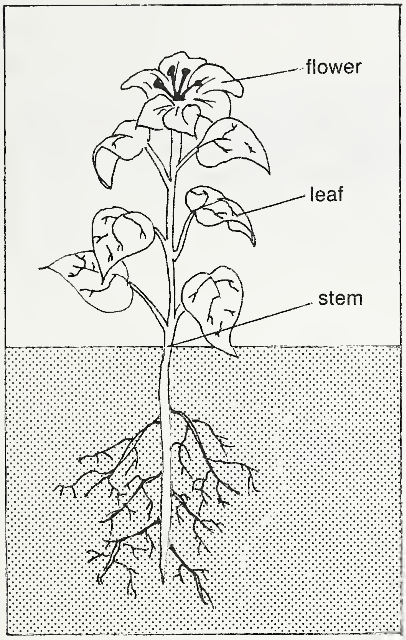
The most important function of the root is to absorb water and inorganic substances from the soil. Secondly, the root serves to support the plant by anchoring it in the soil. Lastly, foods manufactured by plants are carried to the roots to be stored. Common storage roots are found in carrots, beets, turnips, and many other plants.



When a seedling begins to grow, a young shoot pushes out and will become the primary root. The primary root lengthens and pushes its way into the soil. Soon after, roots branch laterally from the primary root to become the secondary roots. These roots begin to appear at first near the top and later farther down, until a complete root system is developed. A short distance from the tip of young roots, white fuzzy growths can be noticed. These growths are root hairs and are very important as they increase the area for the absorption of water and nutrients.

The Plant Shoot

The shoot of developing plants can be divided into three main components: stem, leaves, and buds. The leaf and its role in food production (photosynthesis) will be studied in detail in Lesson 18.



The main function of the stem is conduction as it is able to transport water, minerals and manufactured food throughout the plant. Stems are also important in producing and displaying leaves and flowers. They are also capable of photosynthesis. Lastly, stems are vital in storing water and food reserves.

Herbaceous stems which are soft and green stand up straight because of strengthening fibres and turgor pressure in the cells. Turgor pressure is the result of water moving into the cells by osmosis. Water builds up pressure inside (osmotic pressure) and causes the cells to maintain a rigid position. In turn, this causes the stem to become stiff and hard. Whenever water is lost from the stem, the plant will wilt. Herbaceous stems grow very little in diameter and last only one year. Common examples are stems of corn, grasses, tomatoes, beans and lilies.

Woody stems, in comparison, have greater strength and can attain a greater size because of the tissue they possess. The vascular cambium, a thin layer of cells between the xylem and phloem, is responsible for growth in diameter as it continues to produce additional vascular tissue. These plants also increase in length.

The Plant Bud

Characteristic of plant stems are the buds they possess. These allow for growth in the plant shoot and are the basis for leaf and flower development. There are two types of buds: the axillary or lateral buds and the terminal or apical buds. The axillary buds are on the side of the stem and usually form branches. The terminal bud is at the tip of the plant and is the control centre for growth. The shape of the plant can be modified by cutting off the terminal bud.

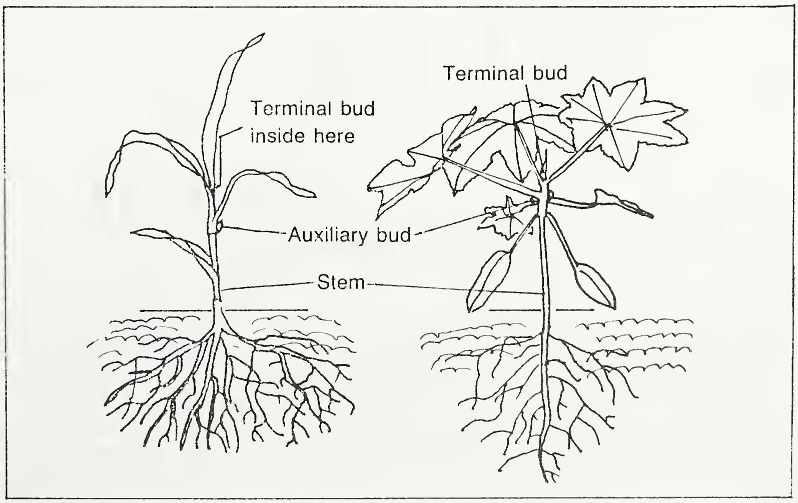


Figure 5: Location of the terminal and axillary buds.

The Flower

Flowers are the reproductive organs in angiosperms. They are composed of four parts: sepals, petals, stamens, and pistils attached to the receptacle - a swollen base at the end of the flower stem. The sepals form the calyx and the petals form the corolla. Please refer to the following diagram for these structures.

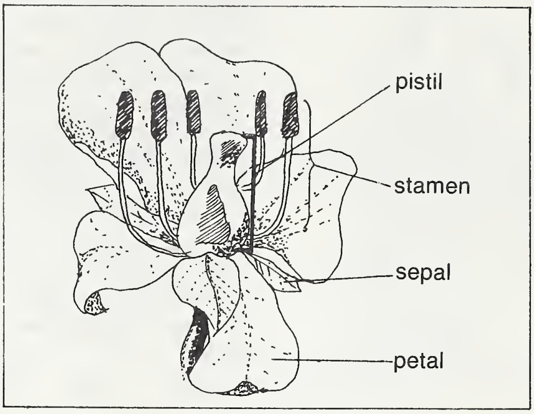


Figure 6: Basic structures of a flower

Sepals and petals are accessory flower parts, and are not essential for fertilization and seed formation. Both can be missing or only one may be present in a flower. Sepals, extending from the receptacle, are green and leaf-like or they can be highly colored. The calyx protects the inner structures of the flower. Petals found inside the sepals are usually elaborately colored. At their base, a special chemical substance is formed which produces distinguishing scents. The scents and colorful petals attract insects responsible for pollinating flowers.

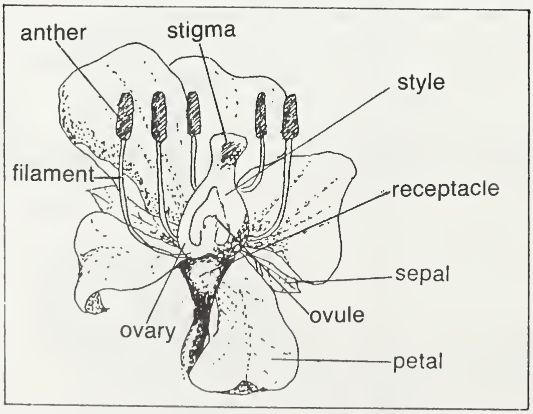


Figure 7: Reproductive structures of the flower

monoecious: contains both male and female reproductive structures

dioecious: having either male or female structures on the plant

Two essential parts of a flower, important in reproduction and seed formation, are the stamens and pistils. The stamen is made up of a slender stalk (the filament) that extends from the base of the flower to a knoblike structure at the top called the anther. The anther produces pollen grains (the male reproductive cells). The pistil is found in the center of the flower. It has a swollen base (the ovary) attached to the receptacle. The ovary contains the female reproductive cells - the ovules. From the ovary, a slender portion (the style) extends upward into the sticky stigma.

Pollination is the transfer of pollen from the anther (male structure) to the stigma (female structure). In plants where both male and female structures are present, self-pollination usually occurs by wind or gravity. In other plants where only one of the structures is present, cross-pollination is necessary. Cross-pollination occurs when the pollen from an anther is transferred to the stigma of another plant. Birds, insects and environmental factors such as wind and water function as agents of cross-pollination.

When the pollen grain lands on the stigma, a pollen tube develops and penetrates the stigma. The pollen tube expands and grows down the style towards the micropyle with the tube nucleus at its tip. As the pollen tube grows the generative nucleus moves into the tube where it divides to form two sperm nuclei. When the pollen tube passes through the micropyle and reaches the embryo sac, the tube digests the cell wall. Then the tube nucleus disintegrates and the sperm nuclei move into the embryo sac.

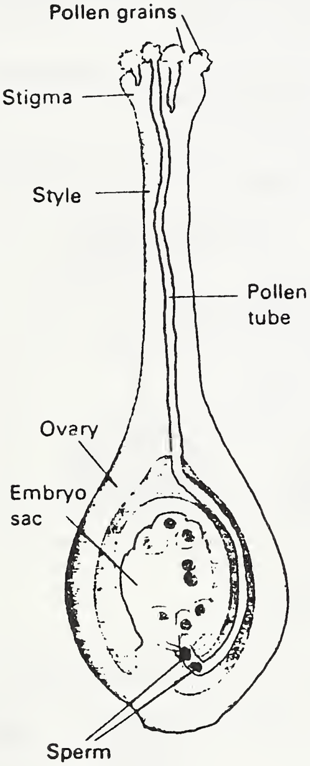


Figure 8: Growth of pollen tube

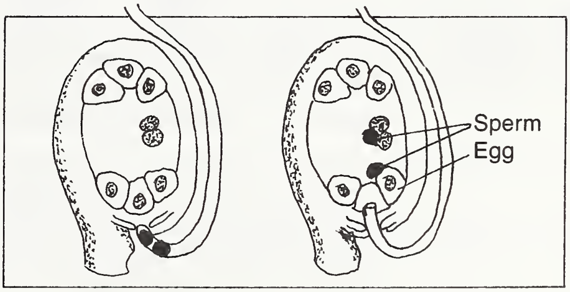


Figure 9: Double Fertilization. Sperm unites with both the egg and the two polar nuclei.

One of the sperm nuclei will unite or fertilize the egg to form a fertilized egg or zygote. Both the sperm nucleus and the egg are haploid. Once the two unite they will be diploid and thus restore the normal chromosome number of 2N. This zygote will undergo numerous cell divisions to form the embryo which matures into the tiny plant. Another sperm nucleus will unite with two polar nuclei resulting in a triploid or 3N. It gives rise to the endosperm which is stored food for the developing embryo. The seed is the embryo and the food storage tissue enclosed by a seed coat.

Germination and Seedling Growth

Germination is the sprouting of the seed and is dependent on water, oxygen, and the proper temperature.

1. Water - Before germination, a seed absorbs vast amounts of water to soften the seed coat. An over-abundance of water can encourage fungal growth and cause the seed to rot.
2. Temperature - The ideal temperature for germination varies with each seed. Peas can germinate in quite cold soil, but corn requires higher temperatures. The best temperature range for the majority of plants is between 15°C and 27°C.
3. Oxygen - As the seedling begins to grow it requires more oxygen to facilitate respiration. It is for this reason seeds are planted near the surface and in loose soil.

Once the seed has germinated seeding development is underway. Development differs in monocots and dicots. Please refer to the diagram below as you continue with the notes.

Definitions:

Epicotyl - portion of seedling stem above the cotyledons

Hypocotyl - portion of the seedling stem below the cotyledons

Cotyledon - embryonic leaf of seed plants

Radicle - embryonic root of seed plants

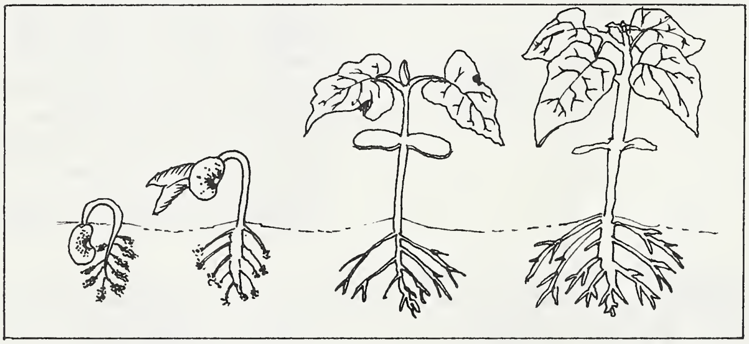


Figure 10: Seedling development of a bean (dicot)

In the dicot (the bean) after the seed coat has softened, the hypocotyl protrudes through the surface. Above ground, the hypocotyl straightens out and lifts the cotyledon up. This is now called the shoot. The tiny leaves that form are true leaves and remain on the plant. The stem continues to grow and develop leaves. As the leaves begin to photosynthesize the cotyledons wither and fall off.

The following diagram illustrates growth in the monocot (corn).

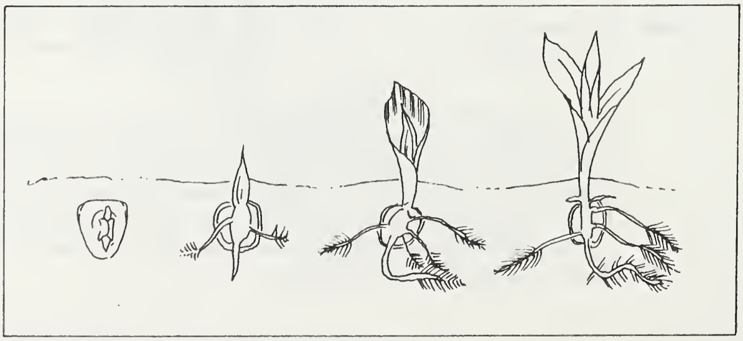


Figure 11: Seedling development of a corn (monocot)

Growth is similar except that the epicotyl pushes through the surface and continues leaf development. The hypocotyl and cotyledon remain below the earth's surface.

Growth Responses

A. External Factors

Environmental factors can affect the growth and development of plants. The effects of temperature, light, soil, water, minerals and moisture in the air are evident on plants. However, plants also respond to environmental stimuli. A tropism is a growth movement determined by the direction from which the stimuli strikes a plant. An example is the response of plants to light by growing towards that stimulus. This is called a positive phototropism. Other responses either toward (positive) or away (negative) from a stimulus include geotropism (gravity) and hydrotropism (water).

A nastic response is independent of the direction an external stimulus strikes the plant. An example of a nastic response is flowers opening in the morning and closing at night.

B. Internal Factors

Plant growth is also regulated internally by plant hormones. Hormones produced in the plant are translocated to other parts of the plant to influence growth, elongation of cells, and division of cells. Two very common hormones are auxins and gibberellins.

Auxins:

These are primary growth hormones in plants found in the tips of stems, leaves, and seeds. A natural auxin is indoleacetic acid (IAA) but a more familiar synthetic auxin is 2,4-D (2, 4-Dichlorophenoxy) acetic acid or NAA (napthalene acetic acid).

Auxins influence growth in a number of ways such as:

1. fruit development - auxins stimulate the growth of fruit and production of seedless fruit (example - grapes, tomatoes)
2. apical dominance - this allows for the plant to assume a dominant terminal bud. Removing the bud will allow lateral branches to increase in height.
3. abscission - refers to the shedding of leaves or fruit. When the auxin supply of a plant decreases an abscission layer forms around the petiole causing leaves to drop. Spraying fruit trees with auxin delays falling of fruit.
4. root initiation - stimulates root development from stem or leaf cuttings. This is dependent upon the presence of auxin translocated from upper portions of the leaf.

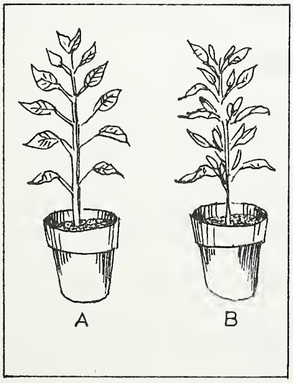


Figure 12: A. Plant with apical dominance B. Terminal bud removed and axillary buds begin to grow.

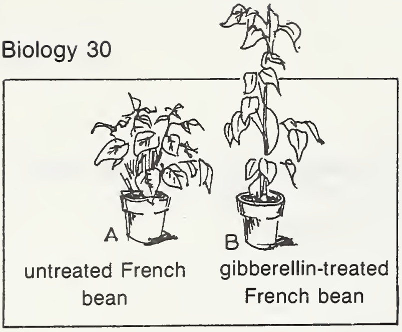


Figure 13: Example of application of gibberellic acid

Gibberellins:

Gibberellins promote growth in plants by increasing the rate of cell division and affect the whole stem. When applied to certain plants, gibberellic acid can promote flower development and sprouting of leaves.

Exercise 3

1. Complete the following statements by filling in the numbered blank on the right.

(a) The two distinct sections of the vegetative stage of a plant are the plant ____(1)____ and ____(2)____ .

(1) ________________

(2) ________________

(b) The dicot root is a ____(3)____ root while the monocot has a ____(4)____ root.

(3) ________________

(4) ________________

(c) An important function of plant roots, such as beets and carrots, to man is ____(5)____ .

(5) ________________

(d) The three components of the shoot of a developing plant are ____(6)____ , ____(7)____ and ____(8)____ .

(6) ________________

(7) ________________

(8) ________________

(e) The build-up of water pressure in a cell to maintain turgor is due to ____(9)____ ____(9)____ .

(9) ________________

____

(f) Woody stems can increase in diameter because of the ____(10)____ which produces additional xylem and phloem.

(10) ________________

(g) The two types of buds are ____(11)____ and ____(12)____ .

(11) ________________

(12) ________________

(h) The ____(13)____ is the reproductive organ in angiosperms.

(13) ________________

(i) The sprouting of a seed is dependent upon ____(14)____ , ____(15)____ and ____(16)____ .

(14) ________________

(15) ________________

(16) ________________

(j) A ____(17)____ response is independent of the direction of the stimuli.

(17) ________________

(k) Plant growth is regulated internally by ____(18)____ .

(18) ________________

(l) Two examples of internal factors that affect plant growth are ____(19)____ and ____(20)____ .

(19) ________________

(20) ________________

2. List 3 functions of the root.

(a) ____________________

(b) ____________________

(c) ____________________

3. List four functions of stems.

(a) ____________________

(b) ____________________

(c) ____________________

(d) ____________________

4. What does a seed consist of?

____

____

____

5. List three uses of auxins.

(a) ____________________

(b) ____________________

(c) ____________________

Please check your work with the answers given on pages 16 and 17.

ANSWERS TO THE KEYED EXERCISES

Exercise 1, pp. 3 and 4.

Complete the statements with the words given below.

(1) **gametophyte**
(2) **nonvascular**
(3) **vascular**
(4) **Gymnospermae**
(5) **Angiospermae**
(6) **sporophyte**
(7) **gametophyte**
(8) **Musci (mosses)**
(9) **Hepaticae (liverworts)**
(10) **Anthocerotae (hornworts)**
(11) **roots**
(12) **stems**
(13) **leaves**
(14) **rhizoids**
(15) **Psilopsida**
(16) **Lycopsida**
(17) **Sphenopsida**
(18) **Pteropsida**

Exercise 2, p. 7.

1. Complete the statements with the words given below.

(1) **sporophyte**
(2) **xylem**
(3) **phloem**
(4) **tomatoes**
(5) **poplar tree**
(6) **African violet**
can vary
(7) **gymnosperms**
(8) **angiosperms**
(9) **spruce**
(10) **pine**
(11) **larch**
(12) **juniper**
(13) **hemlock**
can vary
(14) **cones**
(15) **needles**

2. The following structures distinguish monocots from dicots.

(a) **number of cotyledons**
(b) **leaf venation**
(c) **lack or presence of a cambium and the arrangement of xylem and phloem**
(d) **floral parts**
(e) **root systems.**

Exercise 3, pp. 14 and 15.

1. Complete the statements with the words given below.

(1) **root**
(2) **shoot**
(3) **tap root**
(4) **fibrous**
(5) **storage**
(6) **stem**
(7) **leaves**
(8) **buds**
(9) **osmotic pressure**
(10) **cambium**
(11) **axillary (lateral)**
(12) **terminal (apical)**
(13) **flower**
(14) **oxygen**
(15) **moisture (water)**
(16) **temperature**
(17) **nastic**
(18) **hormones**
(19) **auxins**
(20) **gibberellins**

2. Root functions include:

   (a) **conduction**
   (b) **absorption**
   (c) **storage**

3. Stem functions include:

   (a) **conduction**
   (b) **photosynthesis**
   (c) **storage**
   (d) **producing and displaying leaves (support)**

4. A seed consists of

   (a) **a seed coat**
   (b) **embryo**
   (c) **endosperm**

5. Auxins can be used to **stimulate fruit, produce seedless fruit, alter the shape of a plant, prevent fruit or leaves from dropping, and stimulate root development in cuttings.**

EXERCISES TO BE SENT IN FOR CORRECTION

Part One: Multiple Choice

For each of the following questions, choose the best answer and write the appropriate letter in the blank provided.

______ 1. The ancestors of the modern land plants are

(a) blue-green algae.
(b) green algae.
(c) desmids.
(d) red algae.

______ 2. The liverworts are members of the phylum

(a) Chlorophyta.
(b) Tracheophyta.
(c) Marchantia.
(d) Bryophyta.

______ 3. The plant group that developed vascular tissues includes the

(a) bryophytes.
(b) mosses.
(c) ferns.
(d) liverworts.

______ 4. Most plants found on earth today are members of the

(a) conifers.
(b) mosses.
(c) ferns.
(d) flowering plants.

______ 5. A plant growing away from light is an example of

(a) positive phototropism.
(b) positive photoperiodism.
(c) negative photoperiodism.
(d) negative phototropism.

______ 6. In plants, a response that is independent of the direction of the stimulus is

(a) geotropism.
(b) phototropism.
(c) all tropisms.
(d) a nastic movement.

______ 7. Nastic and trophic responses are similar in that they

(a) are both triggered by stimuli.
(b) are turgor movements.
(c) occur rapidly.
(d) are usually reversible.

______ 8. A substance that promotes root growth in cuttings is

(a) gibberellic acid.
(b) 2,4-D.
(c) DDT.
(d) 2,4,5-T.

______ 9. The function of the flower is

(a) asexual reproduction.
(b) spore production.
(c) sexual reproduction.
(d) to attract insects.

______ 10. A pollen grain can only get as close to the eggs as the

(a) stigma.
(b) style.
(c) ovary.
(d) receptacle.

______ 11. In a seed, the embryonic root is the

(a) radicle.
(b) epicotyl.
(c) hypocotyl.
(d) cotyledons.

______ 12. The bean and the corn seed are similar in that they

(a) both have two cotyledons.
(b) both store most of their food as endosperm tissue.
(c) both contain a dormant embryo.
(d) all of the above.

______ 13. Plants that lack roots, stems and leaves are called

(a) thallophytes.
(b) nonvascular plants.
(c) diatoms.
(d) pteropsida.

______ 14. A root growing into the ground is an example of

(a) a nastic response.
(b) geotropism.
(c) phototropism.
(d) apical dominance.

______ 15. The two major divisions of the plant kingdom are

(a) Bryophyta and Tracheophyta.
(b) Bryophyta and Chlorophyta.
(c) Angiospermae and Gymnospermae.
(d) Chlorophyta and Tracheophyta.

______ 16. Which of the following parts of a root provide the greatest individual total surface area for absorption purposes?

(a) main taproot.
(b) rootlets.
(c) root hairs.
(d) branch roots.

______ 17. Seeds ensure the survival of the embryo by

(a) providing a food store for the embryo once growth starts.
(b) remaining dormant till growth conditions are right.
(c) protecting the embryo from physical injury and damage.
(d) all of the above.

______ 18. The group of plants that produce seeds enclosed within an ovary are the

(a) gymnosperms.
(b) cycads.
(c) conifers.
(d) angiosperms.

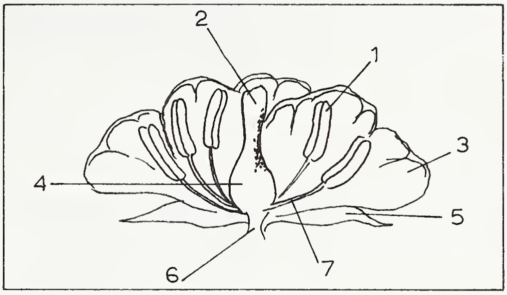
______ 19. Which of the following is **not** a characteristic of conifers?

(a) herbaceous.
(b) needle-like leaves.
(c) cones.
(d) trees or shrubs.

______ 20. Which of the following is **not** a characteristic of angiosperms?

(a) They produce flowers.
(b) They produce fruits.
(c) Seeds are born in cones.
(d) They produce pollen.

21. Place the appropriate numbers from the diagram beside the statements given below. N.B. More than one number may match.



______ (a) adapted for catching pollen

______ (b) produces pollen

______ (c) makes up the calyx

______ (d) makes up the corolla

______ (e) the flower's base

______ (f) may be brightly colored

______ (g) makes up the stamen

______ (h) contains the ovules

22. Arrange the steps in fertilization in the order they occur by placing the letter of the event beside the number that represents the order of the events.

1. Two sperm nuclei are formed.
2. The pollen tube enters the ovule through the micropyle.
3. The egg cell and central cell are fertilized.
4. The pollen tube grows down through the stigma and style.
5. The embryo and endosperm develop.
6. The pollen grain lands on the stigma.

(a) First event ______

(b) Second event ______

(c) Third event ______

(d) Fourth event ______

(e) Fifth event ______

(f) Sixth event ______

______ 23. The endosperm nucleus

(a) is 3N.
(b) develops into a food source for the embryo.
(c) is a part of the central cell.
(d) all the above.

______ 24. The two major groups of flowering plants are the

(a) gymnosperms and angiosperms.
(b) cycads and ginkgoes.
(c) grasses and composites.
(d) monocots and dicots.

______ 25. Monocots do not increase stem diameter because they

(a) have fibrous roots.
(b) are all annuals.
(c) lack a cambium.
(d) all of the above.

Part Two: Fill in the Blanks

1. Complete each of the following statements by filling in the numbered blank on the right.

(a) The major function of stems is that of ___(1)___ . (1) ____________

(b) Stiffness in herbaceous stems is maintained by ___(2)___ ___(2)___ . (2) ____________ ____________

(c) The vascular tissue of dicots consists of cambium, phloem, and ___(3)___ . (3) ____________

(d) The most important function of the root is to absorb water and ___(4)___ substances from the soil. (4) ____________

(5) ____________

(e) The first portion that develops from the young shoot becomes the ___(5)___ root. (6) ____________

(f) The branches produced by the primary roots are called ___(6)___ roots. (7) ____________ ____________

(g) ___(7)___ ___(7)___ develop from the epidermal cells of the root system to increase absorption. (8) ____________

(h) The accessory floral parts are ___(8)___ and ___(9)___ . (9) ____________

(i) The essential floral parts for reproduction are ____(10)____ and ____(11)____ .

(j) Tiny spherical-like structures bearing the male reproductive cells are the ____(12)____ ____(12)____ .

(10) ________

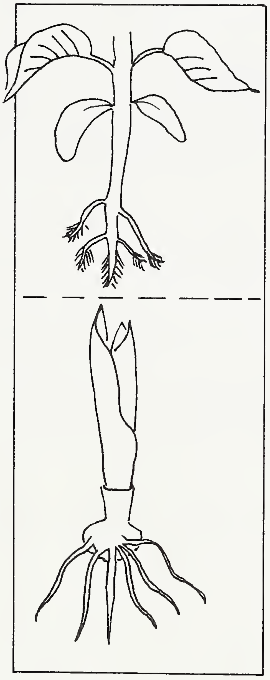
(11) ________

(12) ________

____

Part 3: Short Answer Questions

1. The germinated seeds drawn below are each typical of a monocot or dicot plant. State the type of plant, name an example of a plant you know of this type, then state **three** characteristics of the group.



Type ________________

Example ________________

Three diagnostic characteristics ________________

____

____

Type ________________

Example ________________

Three diagnostic characteristics ________________

____

____

2. Compare the structure of woody and herbaceous plants.

____

____

____

____

____

____

3. What is the major difference in seedling development of monocots and dicots?

4. A house plant is growing tall and spindly, how would you stimulate the plant to branch out instead of continuing upward growth?

5. What are the results of double fertilization in the flower?

6. How could you, as a produce grower, use auxins and gibberellins to your advantage?

Part 4: True or False Questions

Indicate whether the following statements are True or False by circling the correct letter at the beginning of each statement.

T F (a) Apical dominance occurs in lateral buds.

T F (b) Spraying napthalene acetic acid on flowers of nonpollinated tomato plants growing in a green house would produce seedless tomatoes.

T F (c) Trees sprayed with a dilute solution of auxin will hasten abscission.

T F (d) Geranium cuttings dipped in auxin would induce the formation of roots.

Please submit pages 18 to 25 for correction.

END OF LESSON 17

LESSON RECORD FORM

3230 Biology 30

Revised 03/89

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Additional Grading E/R/P Code: ______

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1. BEFORE MAILING YOUR LESSONS, PLEASE SEE THAT:

(1) All pages are numbered and in order, and no paper clips or staples are used.
(2) All exercises are completed. If not, explain why.
(3) Your work has been re-read to ensure accuracy in spelling and lesson details.
(4) The Lesson Record Form is filled out and the correct lesson label is attached.
(5) This mailing sheet is placed on the lesson.

2. POSTAGE REGULATIONS

Do **not** enclose letters with lessons.

Send all letters in a separate envelope.

3. POSTAGE RATES

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Take your lesson to the Post Office and have it weighed. Attach sufficient postage and a **green first-class sticker to the front of the envelope, and seal the envelope. Correspondence lessons will travel faster if first-class postage is used.**

Try to mail each lesson as soon as it has been completed.

When you register for correspondence courses, you are expected to send lessons for correction regularly. Avoid sending more than two or three lessons in one subject at the same time.

OBJECTIVES

Upon completion of Lesson 18, the student should be able to:

1. **Know** the external structure of a leaf.
2. **Label** the internal tissues of a sectional view of a leaf.
3. **Describe** the functions of the tissues of a leaf.
4. **Distinguish** between autotrophs and heterotrophs.
5. **Understand** the workings of the guard cells and stomata.
6. **Describe** the internal structure of a chloroplast.
7. **Explain** what reactions occur in certain areas of a chloroplast.
8. **Understand** major discoveries about photosynthesis.
9. **Understand** the processes of light and dark reactions in photosynthesis.
10. **Know** the difference between cyclic and noncyclic photophosphorylation.
11. **Understand** the process of electron transfer to produce ATP.
12. **Know** how $NADH_2$ is formed.
13. **Understand** how carbohydrates are formed in the dark reaction.
14. **Identify** the end product of photosynthesis.
15. **Identify** and **understand** factors limiting the rate of photosynthesis.
16. **Relate** the importance of photosynthesis to the survival of man.

LEAF STRUCTURE AND PHOTOSYNTHESIS

Introduction

Green plants and algae provide molecules of food upon which living things depend. The process by which large organic molecules are produced is photosynthesis. Organisms capable of providing their own food are **autotrophs**. Other organisms that depend on these preformed molecules to sustain life ar **heterotrophs**.

The process of photosynthesis is dependent on light energy, carbon dioxide, and water. The chief structure which carries out this process is the leaf of a green plant.

The Leaf

A. External Anatomy

Illustrated below are typical examples of various leaf variations and structures.

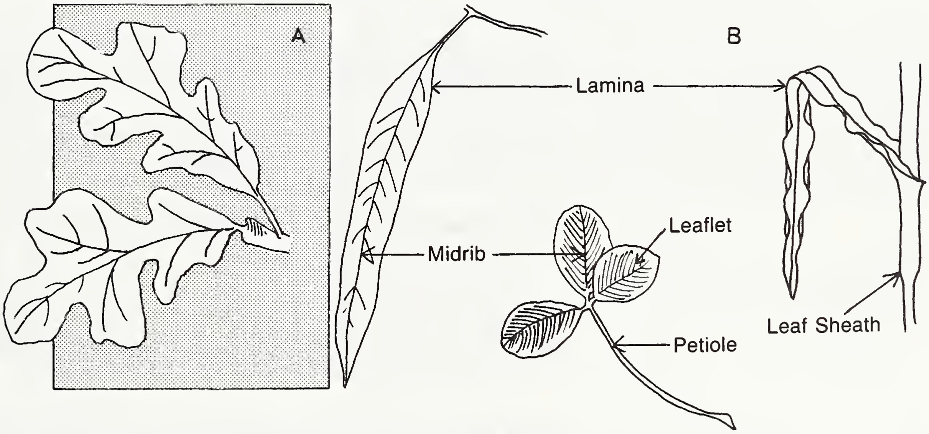


Figure 1: A. Typical Leaf B.Leaf Variations and Structures

The leaf-blade or lamina is attached to the stem by a stalk (or petiole) in a dicot and by a leaf sheath in a monocot. The lamina is vital in photosynthesis as it:

1. traps light energy by the use of two absorbing pigments - chlorophyll *a* and chlorophyll *b*.
2. absorbs carbon dioxide from the environment during daylight.

The primary role of all leaves is that of photosynthesis. In this process, they are able to produce carbohydrates from raw materials - water and carbon dioxide - using sunlight as the energy source. The leaf structure may vary in size and shape to allow the plant to adapt and survive in different environments.

B. Internal Anatomy

Below is a sectional view of a leaf, illustrating the leaf tissues. Use the diagram to better understand the structures and their functions.

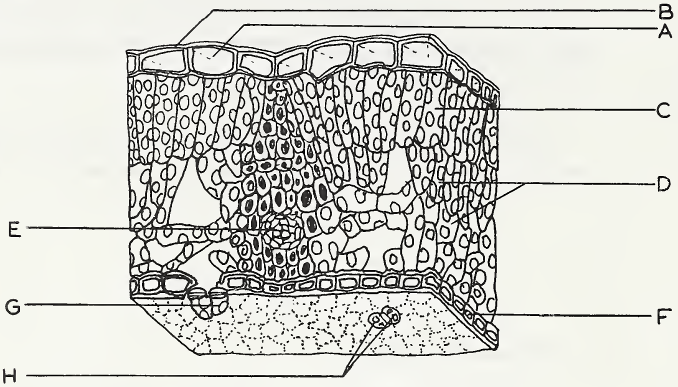


Figure 2: Cross Section of Leaf Illustrating Tissues

Upper epidermis (A) - This layer is one cell thick and secretes a thin transparent layer called the cuticle. The epidermis allows sunlight to pass through.

Cuticle (B) - The cuticle is a thick, waxy layer which prevents water molecules from escaping from the leaf to the atmosphere.

Palisade layer (C) - This layer, beneath the epidermis, contains chloroplasts and is the major site of photosynthesis.

Spongy layer (D) - These cells are more loosely arranged and function in gas exchange of carbon dioxide and in photosynthesis. The spongy layer and palisade layer together form the bulk of the leaf mesophyll.

Veins (E) - Veins are embedded in the mesophyll layer and supply water and nutrients to the tissues of the leaf. They also transport sugar produced in mesophyll cells. The veins connect to the vascular system of the entire plant so sugar can be transported to areas where it is needed - stems, roots, buds, fruits and growing leaves.

Lower epidermis (F) - The bottom leaf layer is a protective one and usually contains stomata.

Stomata (plural), Stoma (singular)**(G)** - These are pores in the epidermis through which gas exchange occurs. CO_2 enters and O_2 produced during photosynthesis exits here. The amount of turgor pressure in the guard cells determines whether or not the stomates will be opened or closed. An unequal inward water pressure causes the cell contents to be pushed against the thinner outer walls. This causes the thicker inner walls to bend, opening the stoma. As water pressure decreases the stoma will close.

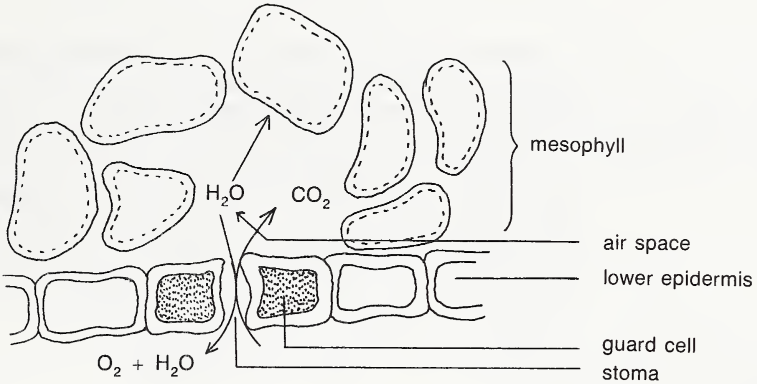


Figure 3: Stoma of a Leaf in Cross Section

Guard cells (H) - These crescent-shaped epidermal cells open and close the stomata. During photosynthesis they help prevent water loss by closing the stomata in dry conditions. Unlike the epidermal cells, guard cells do possess chloroplasts.

Chloroplasts

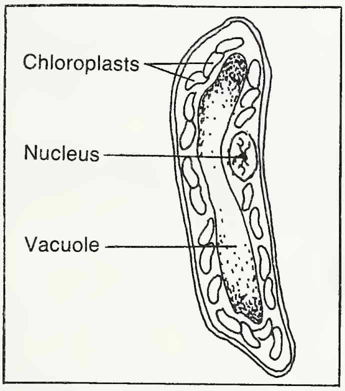


Figure 4: Palisade Cell Illustrating Chloroplasts

Photosynthesis occurs in any cell that contains chloroplasts and is exposed to sunlight. Chloroplasts are tiny structures in the cytoplasm of certain cells - the mesophyll and the guard cells. Within the chloroplast are flattened disc-shaped sacs called **thylakoids**, stacked in piles called **grana**. Grana are made up of lipids, proteins, and chlorophyll. It is in the grana that reactions involving the transfer of light energy to chemical energy occur.

Surrounding the grana in a chloroplast is the stroma - a gel-like substance in which chemical energy is utilized to form carbohydrates.

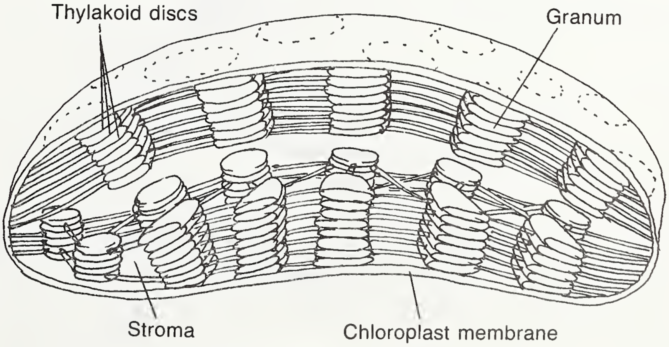


Figure 5: Diagram of a Chloroplast

Chlorophyll is the important compound that is able to absorb light energy. There are four different kinds of chlorophyll - *a*, *b*, *c*, and *d*. However, chlorophyll *a* and *b* seem to be the primary compounds for photosynthesis.

If light is shone through a prism it breaks up into different colors which have different wavelengths. The blue hues of light have short wavelengths while the red hues of light have longer wavelengths. Both of these types of light are absorbed by chlorophyll for photosynthesis. The green hues of light have intermediate wavelengths and are reflected rather than absorbed by the plant. Leaves appear green because of the reflection of these intermediate wavelengths of light by chlorophyll.

Exercise 1

1. Complete each of the following statements by filling in the numbered blank on the right.

   (a) Photosynthesis occurs in cytoplasmic structures called ___(1)___ .

   (b) Chloroplasts contain smaller structures, the ___(2)___ , which contain lipids, proteins and ___(3)___ , the essential compound that absorbs light energy.

   (c) The two essential raw materials for photosynthesis are ___(4)___ and ___(5)___ .

   (1) ____________________

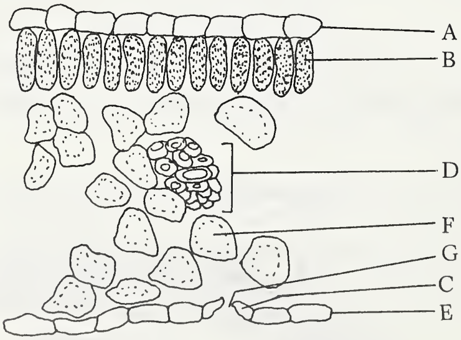
   (2) ____________________

   (3) ____________________

   (4) ____________________

   (5) ____________________

2. In the space at the right give the name of the structure indicated in the cross section of a leaf.



Typical cross section of a leaf

A. ____________________

B. ____________________

C. ____________________

D. ____________________

E. ____________________

F. ____________________

G. ____________________

3. Distinguish between autotrophs and heterotrophs.

____

____

____

Please check your work with the answers given on page 14.

Discovery of Photosynthesis

The process of photosynthesis is vital for man to exist. Without it no large organic molecules nor free oxygen would be produced. The importance of this process was under investigation quite early. The following table illustrates major discoveries about photosynthesis.

Year	Scientist	Discovery
1600's	Jean-Baptist van Helmont, Belgian physician and scientist	Conducted experiments to determine where plant mass accumulates from - soil or water. Provided important information regarding plant growth.
1772	Joseph Priestly, English clergyman and chemist	O_2 is released into the atmosphere by plants
1779 and 1796	Jan Ingenhouz, Dutch physician and naturalist	O_2 is released by green areas of plants only in the presence of light
1804	Nicolas de Saussure, Swiss chemist and naturalist	Plants take in CO_2 as well as produce O_2 during the process of photosynthesis
1845	Jules Robert Mayer, German physicist	Sunlight contributes the energy to make food from CO_2 and H_2O
1960	Melvin Calvin, American biochemist	Formulated chemical steps in conversion of CO_2 and H_2O into simple sugars

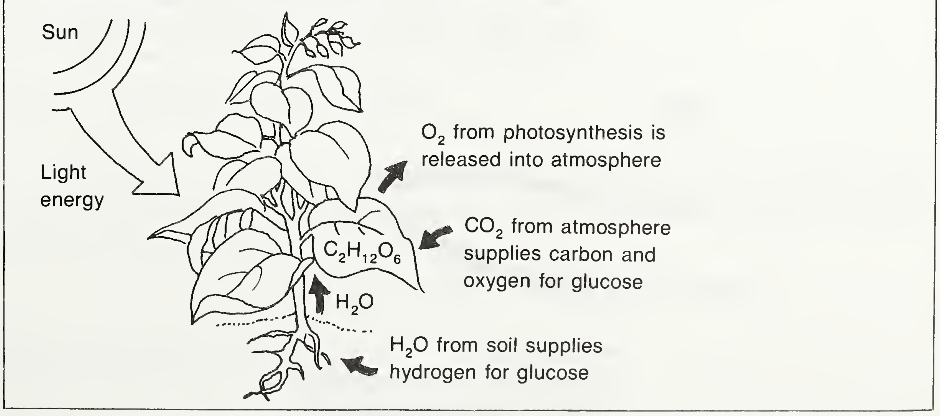

Sun
Light energy
O_2 from photosynthesis is released into atmosphere
CO_2 from atmosphere supplies carbon and oxygen for glucose
$C_2H_{12}O_6$
H_2O
H_2O from soil supplies hydrogen for glucose

Figure 6: Movement of raw materials and production of sugar and oxygen.

The Process of Photosynthesis

Photosynthesis applies to the total process by which carbohydrates are formed from CO_2 and H_2O - in the presence of enzymes, chlorophyll, and light.

Light is directly involved for only the first energy producing stages known as photolysis or the light reactions. Light reactions occur in the grana of chloroplasts where chlorophyll is located. In the light reaction, two products are formed - ATP and $NADH_2$. These unstable compounds are used to "fix" CO_2 into carbohydrates in the dark reactions.

ATP is unstable since a phosphate group of this molecule can break off readily and release energy. Generally, to make ATP, energy must be added to an ADP molecule. This energy, in photosynthesis, comes from light.

$$\mathrm{ADP} + \mathrm{P} + \text{energy} \rightleftharpoons \mathrm{ATP} + H_2O$$

NAD is an electron carrier and during photosynthesis $NADH_2$ forms. This molecule transfers the electrons, protons and energy needed to form carbohydrates in the dark reaction.

The dark reactions take place in both dark or light environments and occur within the stroma of chloroplasts. In this reaction, CO_2, hydrogen, energy from ATP, and $NADH_2$ are used to produce carbohydrates.

The Light Reaction (Photolysis)

The overall effect of the light reaction is two-fold: **to convert light energy to ATP** and **to reduce NAD to $NADH_2$**.

The term photolysis indicates that water is split into hydrogen and oxygen atoms. Experimental evidence shows that the oxygen gas produced during photosynthesis comes from water and not from carbon dioxide.

When sunlight reaches the leaves' chloroplasts, a photon to light energy strikes an electron of the chlorophyll molecule, as a result the electron may be dislodged and moved to a higher orbital (energy level). The chlorophyll is said to be in the "excited electron state." Two things can then happen to the dislodged (excited) electrons:

1. It can be recaptured by the chlorophyll (now positively charged) to produce heat and red light. This process is called fluorescence and the energy produced does not contribute to the photosynthetic process. Refer to the following diagram.

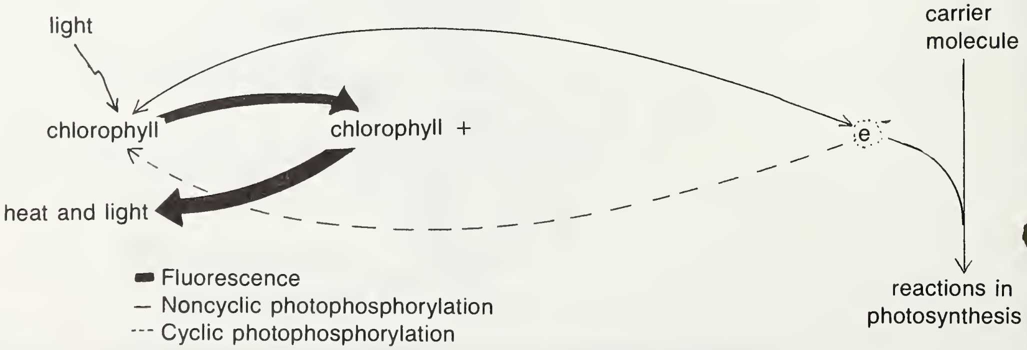

light
carrier molecule
chlorophyll
chlorophyll +
e
heat and light
reactions in photosynthesis
▬ Fluorescence
— Noncyclic photophosphorylation
--- Cyclic photophosphorylation

Figure 7: Pathways of Dislodged Electrons

2. Electrons can be captured by carrier molecules and then be transferred to other carriers. In the process, the electrons release energy that is harvested as ATP. There are two basic pathways by which electrons are transferred - noncyclic photophosphorylation (in which water is split and leads to the production of carbohydrates) and cyclic photophosphorylation (in which the excited electrons are returned to the same chlorophyll molecules, and ATP is formed).

A. Noncyclic Photophosphorylation

Refer to the following diagram as you read through the steps involved in the production of $NADH_2$.

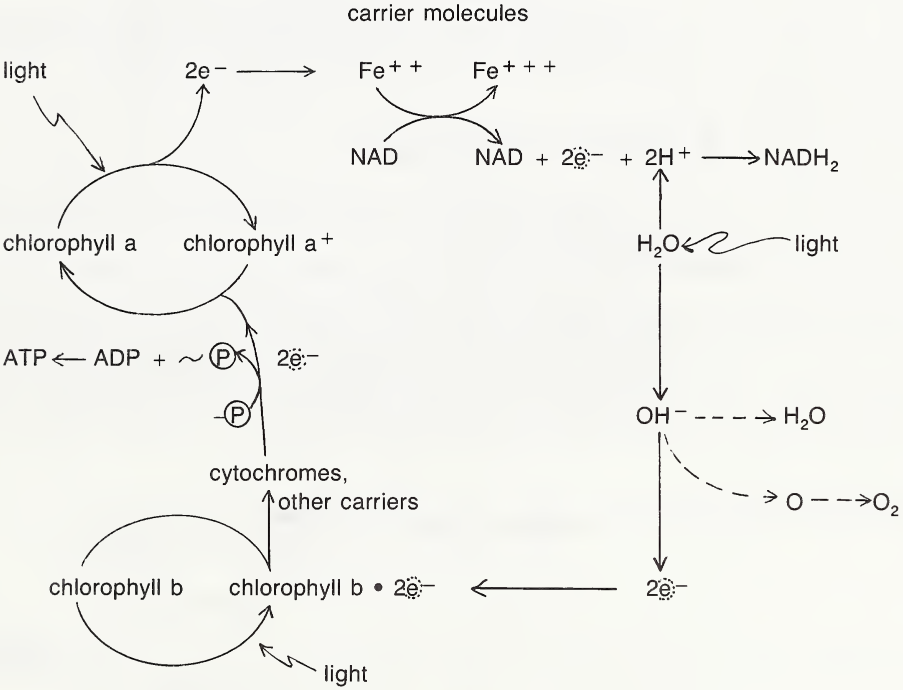


Figure 8: Noncyclic Electron Transfer

In the first step, chlorophyll *"a"* absorbs light. The excited electrons are passed to NAD. At the same time water molecules are split to produce H^+ and OH^- ions. The electrons and H^+ ions combine to form $NADH_2$.

$$2e + 2H^+ + NAD \longrightarrow NADH_2$$

Some water exists in the ionized state.

$$H_2O \longrightarrow H^+ + OH^-$$

The hydroxyl ions (OH^-) combine with each other to form a water molecule and an oxygen atom. The oxygen atoms form a gas that escapes. These reactions are summed up below.

$$2\ OH^- \longrightarrow H_2 + O + e^-$$

$$O + O \longrightarrow O_2\ \text{(gas)}$$

In this process, the electrons released are picked up by chlorophyll ''*b*''. When chlorophyll accepts the electrons and is illuminated, the electrons are brought to a high energy level. These electrons then are transferred to chlorophyll ''*a*'' by carrier molecules. In the transfer, electron energy is released and harvested as ATP.

This process is noncyclic as the electrons needed to replace those from chlorophyll ''*a*'' come from the water molecule in the chloroplast.

B. Cyclic Photophosphorylation

Supplementary ATP required by dark reactions is believed to be supplied by cyclic photophosphorylation.

In this cycle, chlorophyll becomes excited and the electron is dislodged and captured by a carrier molecule (an iron containing coenzyme). The electron moves onto a series of carriers which are collectively called **cytochromes**. In the transfer, electron energy is released to form high energy bonds. The cytochromes transfer the electron to chlorophyll which is positively charged. The energy released is used to produce ATP.

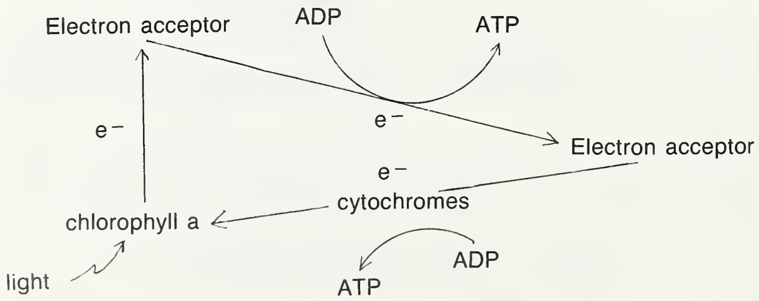


Figure 9: Production of ATP in cyclic photophosphorylation

Cyclic photophosphorylation is a cyclic process because electrons travel in a circle: from chlorophyll back to chlorophyll. At first, the dislodged electron is at a high energy level but when it returns it is at a lower energy level. The energy lost is harvested to produce ATP.

Exercise 2

1. Complete each of the following statements by filling in the numbered blank on the right.

   (a) The scientist who studied the relationship of soil to plant mass was $\underline{\quad (1) \quad}$.

   (b) $\underline{\quad (2) \quad}$ formulated the outline of carbohydrate production.

   (c) The discovery that O_2 is released to the atmosphere by plants in the presence of light was made by $\underline{\quad (3) \quad}$.

   (d) $\text{ADP} + \sim \textcircled{P} \longrightarrow \underline{\quad (4) \quad}$.

   (e) $\text{NAD} + H_2^{+} + 2e^{-} \longrightarrow \underline{\quad (5) \quad}$.

   (1) ____________________

   (2) ____________________

   (3) ____________________

   (4) ____________________

   (5) ____________________

2. What events take place when light strikes a chlorophyll molecule?

3. A water molecule in the ionic state is $H^{+} + OH^{-}$. In the light reaction what happens to the H^{+}? to the OH^{-}?

4. What is the overall effect of the light reaction?

5. What are the two major differences between cyclic and noncyclic photophosphorylation?

(a) ______________________________

____

____

(b) ______________________________

____

____

Please check your work with the answers given on page 14.

The Dark Reaction - Carbon Dioxide Fixation

The reactions of carbon dioxide fixation are complex and were first explained by Dr. Calvin. It is for this reason the cycle used to make carbohydrates is also referred to as the Calvin cycle. The end products of the light reaction formed in the grana of the chloroplasts - ATP and $NADH_2$, enter the stroma. Carbon dioxide also enters the chloroplast.

Hydrogen from $NADH_2$ combines with carbon dioxide to produce the basic carbohydrate - PGAL (phosphoglyceraldehyde). This reaction follows a cyclic sequence that occurs in the dark. The energy for the reaction is supplied by ATP. The three basic steps involved in this process are illustrated in the diagram below (the Calvin cycle).

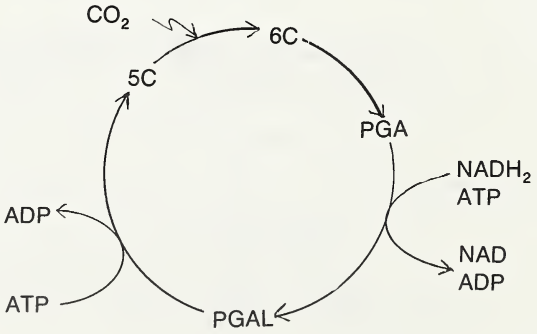


Figure 10: Carbon Dioxide Fixation Cycle (Calvin Cycle)

1. CO_2 enters this cycle as a raw material and reacts with a 5 carbon compound (5C) to form an unstable 6 carbon molecule (6C). This 6C molecule breaks down into two molecules, each having 3 carbon atoms (3C). The 3C molecule is PGA.
2. After PGA is formed, $NADH_2$ enters the cycle to produce the basic simple compound PGAL which is the end product of photosynthesis.

3. Some of the PGAL is converted to glucose or is used directly in the cell. However, a high percentage (80%) of the PGAL remains in the cycle to regenerate the 5C molecule that combines with CO_2 again.

In autotrophs, PGAL is mainly used to regenerate the 5C molecule for the continuation of the carbon dioxide fixation cycle. PGAL is, however, also used to produce glucose. Two PGAL molecules (3C) combine to form one glucose molecule (6C). Heterotrophs depend on the glucose produced by autotrophs to sustain life. Heterotrophs use a process known as cellular respiration to break down glucose and produce energy. This energy can then be used to power the cellular processes of the heterotrophs.

Below is a summary, in diagram form, of the light and dark reactions that occur in different areas within the chloroplast.

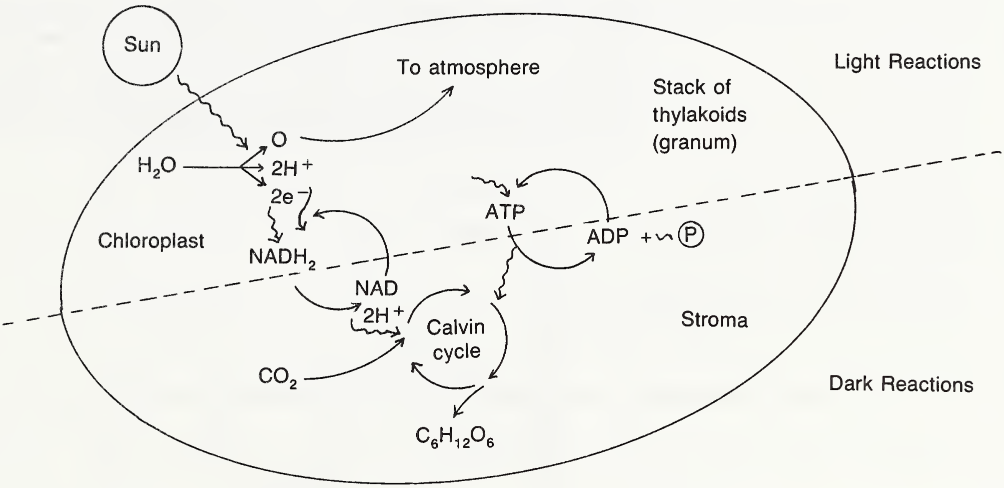


Figure 11: Summary of Light and Dark Reactions

The End Product of Photosynthesis

The end product of photosynthesis is the basic carbohydrate PGAL and it can be used in three basic ways.

1. PGAL can be used immediately in photosynthesizing cells for respiration or to synthesize a structural compound.
2. A minute amount of PGAL is used directly by photosynthesizing cells, with most of it being exported to nonphotosynthetic cells. For export, PGAL is converted into glucose, fructose or sucrose.
3. A large amount of PGAL is converted into compact molecules for storage purposes. It can be stored as fructose or sucrose (eg. sugar cane, sugar beet). The simple sugars combine to form starch - the main storage carbohydrate in plants. Carbohydrates can also be converted to lipids, like sunflower or rapeseed oil.

Factors Limiting the Rate of Photosynthesis

The rate at which plants photosynthesize depends on physical factors such as temperature, CO_2 supply, the kinds and amounts of light, water supply, and availability of minerals.

1. **Temperature** - The rate of photosynthesis rises in a geometric pattern until it reaches temperatures of 30°C to 35°C. When the temperature exceeds 35°C, the rate of photosynthesis decreases sharply.

2. **CO_2 Supply** - CO_2, a raw material for photosynthesis, is obtained from the air. The atmosphere contains only about 0.03% of CO_2 but when CO_2 is added under artificial conditions, the rate of photosynthesis increases until a maximum point is reached. Then, it levels off. The average maximum point for most plants is around 0.5 to 1.0% CO_2 in the atmosphere.

3. **Kind and Amount of Light** - The quality, intensity and duration of light all affect the rate of photosynthesis. Different parts of the spectrum are absorbed in different amounts. The red end of the spectrum provides the most energy for photosynthesis. Blue light provides about half the energy of red light. Green light provides the least amount of energy for photosynthesis. However, all light rays of the spectrum are essential for a maximum rate of photosynthesis.

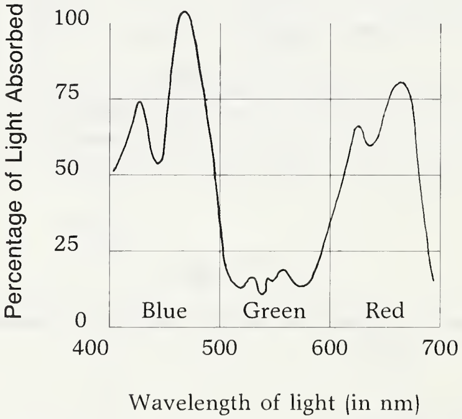


Figure 12: Absorption Spectrum of chlorophyll a and b

The rate of photosynthesis increases from low light intensity until it reaches a maximum point. Plants vary as to their maximum rate of photosynthesis but it is usually at about one-third of full normal sunlight.

The duration of light is an important factor. This becomes evident as plants decrease their photosynthetic rate in short autumn days. During this period the supply of chlorophyll dwindles and other pigments, known as carotenoids, show through with colors of orange and yellow.

4. **H_2O Supply** - The rate of photosynthesis is not affected until the water level is so low that wilting occurs.

5. **Availability of Minerals** - If leaves do not synthesize enough chlorophyll, they become pale and do not photosynthesize. This condition is **chlorosis**. Plants require nitrogen and magnesium to manufacture chlorophyll. Other mineral deficiencies of trace amounts of iron, zinc, copper or manganese may also cause this deficiency.

Exercise 3

1. Complete each of the following statements by filling in the numbered blank on the right.

(a) The cycle used to make carbohydrates is referred to as the ____(1)____ or ____(2)____ ____(2)____ ____(2)____ cycle.

(b) ____(3)____ enters the cycle to react with a 5C molecule to form a 6C molecule.

(c) The end product of photosynthesis is ____(4)____ in the above cycle.

(1) ____________________

(2) ____________________

____

____

(3) ____________________

(4) ____________________

2. What is the end product of photosynthesis used for? State three uses.

(a) ____

(b) ____

(c) ____

3. List the five factors that affect photosynthesis.

(a) ____

(b) ____

(c) ____

(d) ____

(e) ____

Please check your work with the answers given on pages 14 and 15.

ANSWERS TO THE KEYED EXERCISES

Exercise 1, p.4.

1. (1) **chloroplasts**
   (2) **grana**
   (3) **chlorophyll**
   (4) **water**
   (5) **carbon dioxide**

2. A. **upper epidermis**
   B. **palisade layer**
   C. **guard cell**
   D. **vein**
   E. **lower epidermis**
   F. **spongy layer**
   G. **stoma**

3. **autotrophs** - are capable of synthesizing their own food molecules using a source of energy.

   heterotrophs - cannot synthesize their own food and are dependent upon preformed molecules of autotrophs.

Exercise 2, pp.9 and 10.

1. (1) **van Helmont**
   (2) **Calvin**
   (3) **Ingenhouz**
   (4) **ATP**
   (5) **$NADH_2$**

2. When light strikes a chlorophyll molecule it becomes excited as the sun's energy is absorbed and electrons are released.

3. The hydrogen ion (H^+) becomes attached to NAD. Two H^+ combine with a molecule of NAD to form $NADH_2$. The hydroxyl ion (OH^-) will lose its electron to the cytochromes and then 2 OH^- combine to form water and oxygen.

4. The overall effect of the light reaction is two-fold:
   (a) to convert light energy to ATP.
   (b) to reduce NAD to $NADH_2$

5. (a) **Noncyclic photophosphorylation** - produces $NADH_2$ plus oxygen and requires electrons from photolysis of a water molecule to replace those from chlorophyll ''a''.

   (b) **Cyclic photophosphorylation** - produces ATP to be used in dark reactions, and electrons which travel in a circle - from chlorophyll and back to chlorophyll.

Exercise 3, p.13.

1. (1) **Calvin**
   (2) **carbon dioxide fixation**
   (3) **CO_2**
   (4) **PGAL**

2. (a) used immediately for **respiration**
   (b) **transported** to nonphotosynthetic cells
   (c) **converted** to larger molecules for storage

3. (a) **temperature**
   (b) **carbon dioxide supply**
   (c) **kind and amount of light**
   (d) **water supply**
   (e) **availability of minerals**

EXERCISES TO BE SENT IN FOR CORRECTION

Part One: Multiple Choice

For each of the following questions, choose the best answer and write the appropriate letter in the blank provided.

______ 1. The primary function of a leaf is

(a) photosynthesis.
(b) respiration.
(c) storage.
(d) CO_2 uptake.

______ 2. The tissues of a leaf are not primarily designed to

(a) allow penetration of light.
(b) store large amounts of food.
(c) exchange gases.
(d) conduct materials.

______ 3. The epidermis of a leaf is different from the mesophyll because the epidermis

(a) usually lacks chlorophyll.
(b) doesn't have a cuticle.
(c) is several layers of cells thick.
(d) cells lack the ability to respire.

______ 4. The cells that are involved in controlling the movement of water vapour in and out of the leaf are the

(a) palisade mesophyll cells.
(b) epidermal cells.
(c) guard cells.
(d) xylem cells.

______ 5. In a leaf, the CO_2 that is used in photosynthesis reaches the mesophyll via the

(a) xylem.
(b) phloem.
(c) stomata.
(d) petiole.

______ 6. Guard cells have

(a) thin inner walls and lack chloroplasts.
(b) thick inner walls and chloroplasts.
(c) thin inner walls and chloroplasts.
(d) thick inner walls and lack chloroplasts.

______ 7. The major site of photosynthesis in a plant leaf is the

(a) upper epidermis.
(b) spongy layer.
(c) palisade layer.
(d) guard cells.

______ 8. Plants turn color in the fall with disappearance of

(a) chlorophyll.
(b) xanthophyll.
(c) carotene.
(d) anthocyanin.

______ 9. A green alga, such as chlorella, would show least growth when exposed to light of which color?

(a) red
(b) blue
(c) yellow
(d) green

______ 10. The absorption spectrum of chlorophyll shows that it best absorbs wavelengths of light that are ____ and ____ .

(a) green and yellow
(b) blue and red
(c) blue and yellow
(d) green and red

______ 11. A plant which lacks chloroplasts does **not**

(a) give off CO_2.
(b) give off O_2.
(c) take in water.
(d) take in food.

______ 12. Which of the following is **not** true of photolysis?

(a) takes place in chloroplasts
(b) results indirectly in build up of organic molecules
(c) liberates free phosphorus
(d) is regulated by enzymes

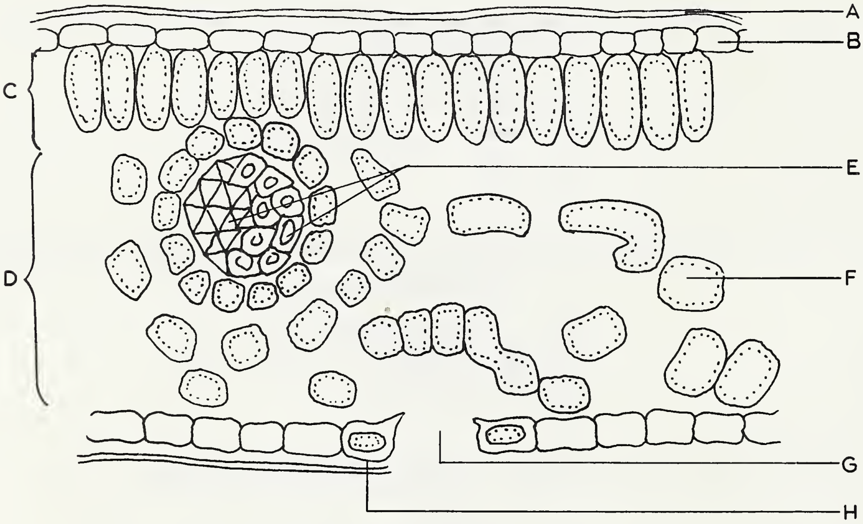
______ 13. A coenzyme that carries hydrogen atoms from the light reactions to the dark reactions is

(a) NAD
(b) ATP
(c) chlorophyll
(d) ADP

______ 14. Energy is carried from the light reactions to the dark reactions by

(a) ADP.
(b) ATP.
(c) CO_2.
(d) activated chlorophyll.

15. Place the appropriate letters from the diagram beside the statement they match. **NB. Each letter may be used more than once.**



______ cells which secrete a vapor barrier.

______ an opening in a leaf.

______ epidermal cells that contain chloroplasts.

______ a water conducting tissue.

______ irregularly spaced photosynthetic cells.

______ provides for internal movement of gases.

______ conducting and supporting tissues.

______ carries on the majority of photosynthesis.

______ reduces water loss from a leaf.

Part Two: Fill in the Blanks

1. Complete each of the following statements by filling in the numbered blank on the right.

(a) The pigments used directly to supply energy in photosynthesis are ____(1)____ and ____(2)____ .

(b) The dark reaction occurs in the ____(3)____ of the chloroplast.

(c) Light reactions occur in the ____(4)____ of the chloroplast.

(d) The gas released as a by-product of photosynthesis is ____(5)____ .

(e) The raw material which O_2 comes from is ____(6)____ .

(f) The carbon used to produce carbohydrates comes from ____(7)____ .

(g) The hydrogen in the basic carbohydrate comes from ____(8)____ .

(h) The raw material which is photolyzed is ____(9)____ .

(i) The carbon in the basic carbohydrate produced in the dark reactions comes from ____(10)____ .

(1) ____________________

(2) ____________________

(3) ____________________

(4) ____________________

(5) ____________________

(6) ____________________

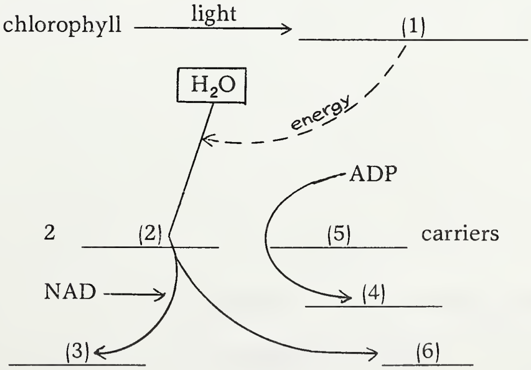
(7) ____________________

(8) ____________________

(9) ____________________

(10) ____________________

2. On the simplified scheme of noncyclic photophosphorylation fill in the appropriate blanks with the following: $NADH_2$, ATP, H^+, excited chlorophyll, O_2, cytochrome.



(1) ____________________

(2) ____________________

(3) ____________________

(4) ____________________

(5) ____________________

(6) ____________________

Part Three: Short Answer Questions

1. How would the condition of chlorosis develop in plants?

2. What are the major functions of the light reactions?

3. What is the end result of the dark reactions?

4. Why is the process of photosynthesis so vital to the survival of man?

Please submit pages 16 to 20 for correction.

END OF LESSON 18

LESSON RECORD FORM

3230 Biology 30
Revised 03/89

FOR STUDENT USE ONLY

Date Lesson Submitted ______________________

Time Spent on Lesson ______________________

(If label is missing
or incorrect)

File Number ______________________

Lesson Number ____________

FOR SCHOOL USE ONLY

Assigned
Teacher: __________

Lesson Grading: ________

Additional Grading
E/R/P Code: ________

Mark: ____________

Graded by: ____________

Assignment Code: ______

Date Lesson Received:

____

Lesson Recorded ______

Student's Questions and Comments

Apply Lesson Label Here

Name

Address

Postal Code

Please verify that preprinted label is for correct course and lesson.

Teacher's Comments:

____
Correspondence Teacher

St. Serv. 1-86

ALBERTA CORRESPONDENCE SCHOOL

MAILING INSTRUCTIONS FOR CORRESPONDENCE LESSONS

1. BEFORE MAILING YOUR LESSONS, PLEASE SEE THAT:

(1) All pages are numbered and in order, and no paper clips or staples are used.
(2) All exercises are completed. If not, explain why.
(3) Your work has been re-read to ensure accuracy in spelling and lesson details.
(4) The Lesson Record Form is filled out and the correct lesson label is attached.
(5) This mailing sheet is placed on the lesson.

2. POSTAGE REGULATIONS

Do **not** enclose letters with lessons.

Send all letters in a separate envelope.

3. POSTAGE RATES

First Class

Take your lesson to the Post Office and have it weighed. Attach sufficient postage and a **green first-class sticker to the front of the envelope, and seal the envelope. Correspondence lessons will travel faster if first-class postage is used.**

Try to mail each lesson as soon as it has been completed.

When you register for correspondence courses, you are expected to send lessons for correction regularly. Avoid sending more than two or three lessons in one subject at the same time.

OBJECTIVES

Upon completion of Lesson 19, the student should be able to:

1. **Understand** the medical dangers of smoking.
2. **Understand** the formation of cancer.
3. **Distinguish** between the two types of tumors.
4. **Know** how lung cancer develops.
5. **Understand** how to prevent lung cancer.
6. **Understand** the hazards of second-hand smoke on nonsmokers.
7. **Distinguish** between mainstream and sidestream pollution.
8. **Understand** how carbon monoxide affects the body.
9. **Know** and **identify** carcinogens.
10. **Know** the dangers of smoking on fetal development.
11. **Understand** the complications of pregnancy due to tobacco.
12. **Understand** how advertising ''sells'' smoking.
13. **Understand** how alcohol affects the nervous system.
14. **Know** what abuse of alcohol can do physically and internally.
15. **Define** cirrhosis of the liver.
16. **Understand** the cause of cirrhosis of the liver.
17. **Know** what Fetal Alcohol Syndrome (FAS) is.
18. **Understand** the physical and mental damages alcohol produces on a fetus.
19. **Know** the ''cure'' for FAS.
20. **Understand** how drinking affects driving.
21. **Know** the three categories of drugs.
22. **Understand** how drugs affect the nervous system.
23. **Be familiar** with the drug guide and short and long term effects of drug use.

TOBACCO, ALCOHOL AND DRUGS

Introduction

Tobacco, alcohol and drugs are self-inflicted substances that can result in serious health problems, physically and emotionally. Each can harm the user and people close to the user. As tobacco, alcohol, and drugs become overused or abused the detrimental effects on the user's body become more apparent. It is at this stage people close to the abuser of these stimulants and depressants may also be affected.

Tobacco

Cigarette smoke contains **carcinogens** or cancer-producing substances. It also contains nicotine, a toxic substance which affects the nervous system. At first, nicotine acts as a stimulant but later it becomes the cause of a habit-forming problem and acts as a depressant. Cigarette smokers inflict the dangers of cancer and respiratory diseases on themselves and others.

Lung cancer is now one of the best known and most feared of all diseases. At least 90% of the disease is related to smoking, although other substances such as asbestos and coal tar products can also cause lung cancer. The other inhaled cancer-producing substances increase the risk for the smoker. Not only does smoking contribute to lung cancer but also to cardiovascular disease and other chronic lung diseases such as emphysema.

Today lung cancer is the leading cause of death from cancer in men and the third leading cause in women. If present smoking trends in women continue, lung cancer will surpass all other forms of cancer as the cause of death.

Cancer

Cancer is a disease in which normal cells in some organ or tissue go out of control, abnormally growing and increasing in number. Normal cells reproduce themselves throughout life, but in an orderly and controlled manner. As normal growth occurs, worn out tissues are replaced and wounds heal. When cells grow out of control they form a mass called a **tumor**. Some tumors grow and enlarge only at the site where they begin. These are referred to as **benign tumors**. Other tumors not only enlarge locally but also have the potential to invade and destroy the normal tissue around them and to spread to distant parts of the body. Such tumors are called **malignant tumors**, or cancer. The distant spread of a cancer occurs when malignant cells detach themselves from the original (**primary**) tumor, are carried to other parts of the body through the blood or lymphatic vessels and establish themselves in the new site as an independent (**secondary**) cancer. A tumor that has spread in this manner is said to have metastasized and the secondary tumor (or tumors) is called a **metastasis** (or metastases).

Lung Cancer

As cigarette smoking is the major cause of lung cancer today, it is important to understand how it affects the lungs. Smoking causes lung cancer in two ways. First of all, smoke inhalation damages the normal cleansing processes by which the lung protects itself from injury. The tube-like structures (bronchi) which conduct inhaled air to the lung tissue are lined with a single layer of cells on which lies a protective coating of mucus.

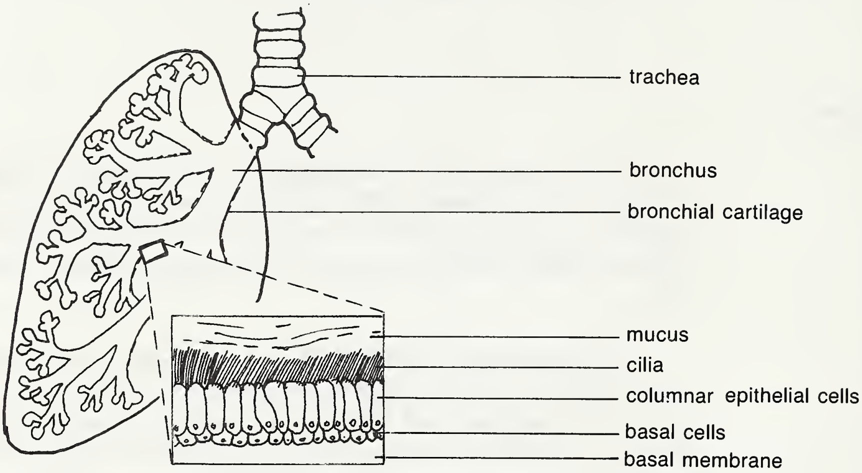


Figure 1: Cleansing Action of Cilia in a Bronchiole

Hair-like cilia on these cells beat in rhythmic fashion to move the mucus continually upwards from the lung, removing any inhaled particles which have been trapped in the sticky mucus. The effectiveness of this cleansing mechanism is destroyed very quickly by smoke inhalation because the cilia cannot function and the lining thickens in an attempt to protect the delicate underlying tissues from damage.

When these changes have occured, the lung can no longer keep itself clean. Consequently, cancer-producing agents in cigarette smoke remain trapped in the mucus on the surface lining of the airway long enough to pass into the cells before these substances can be removed by coughing, the only cleansing mechanism which remains. Once within the body, these chemicals, or their products, can alter the nature of the cells slowly and progressively until cancer develops. Other inhaled carcinogens will represent an additional hazard for the smoker once the effective cleansing function no longer protects the lung.

It is important to realize that once the cause of damage - tobacco smoke - is withdrawn, the cleansing action of the lung can be repaired. It is never too late to stop smoking.

The risk of lung cancer increases with the total amount of exposure. In cigarette smoking, several factors are involved in determining the actual exposure, including the duration of smoking, the number of cigarettes smoked and the depth of inhalation.

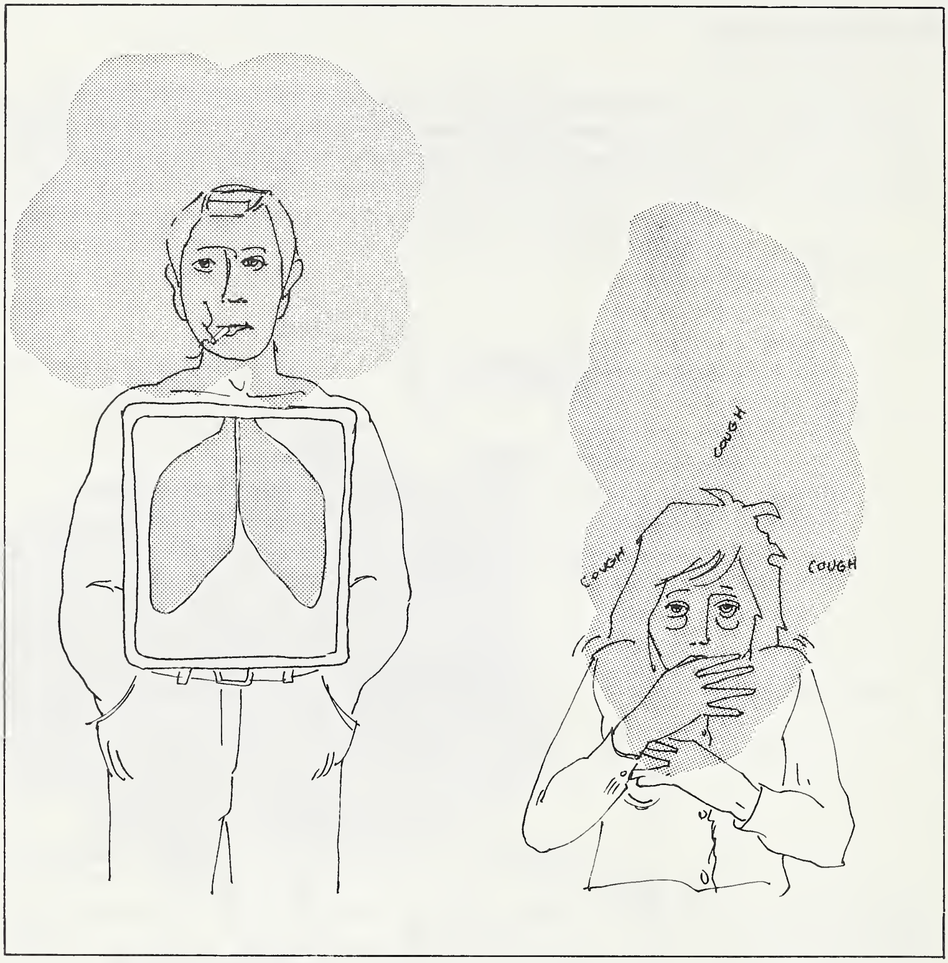
Second-Hand Smoke

The second-hand smoke that reaches non-smokers consists of two types of smoke. Firstly, it is the exhaled smoke referred to as **mainstream pollution**. Secondly, it is the smoke escaping from a burning cigarette referred to as **sidestream pollution**.

Mainstream Pollution

Except for the fact that the odour of exhaled tobacco smoke can be stomach-turning to some people, mainstream pollution offers the lesser hazard to a non-smoker. It consists of the smoke that smokers draw in, hold in their lungs for a while, and then breathe out.

It is to your advantage that smokers hold the smoke in their lungs, for in so doing, they act as a kind of filter, retaining within their own body significant amounts of gases and solid particles that would otherwise be available to you. For instance, a smoker will retain 54% of all the carbon monoxide inhaled and over 90% of all the solid smoke particles - to the smoker's detriment, not yours. This "filtration" takes off a lot of the edge of mainstream pollution as far as you are concerned.



Sidestream Pollution

The sidestream pollution represents the smoke that doesn't enter the smoker's mouth — smoke that escapes from the burning tip of a cigarette and from its butt. Some of the smoke is made up of substances that are in a gaseous state when warm, but which become sticky solids upon cooling off. These "tars" condense on anything that is at normal room temperature, for example on smokers' hair and clothing, giving them a characteristic musty odor. All the tar that doesn't condense on the smoker is left over for the non-smoker.

Besides tainting your hair and clothes, sidestream smoke presents some very real health risks. Non-smokers may incur mild headaches and are bound to suffer some discomfort from eye irritation due to smoke exposure. If they have allergies that affect breathing, such as hay fever or asthma, they will experience other problems as well. Sidestream smoke triggers nasal discomforts such as irritation and a runny nose, causing them to cough and wheeze far more than non-allergic persons.

The primary sidestream smoke hazard lies in its **carbon monoxide content**. Carbon monoxide is one of the simplest, yet most deceptive gases known to chemists. Because it is colorless and odourless, it is virtually undetectable. One of its first effects is to make you dull and perhaps a little sleepy.

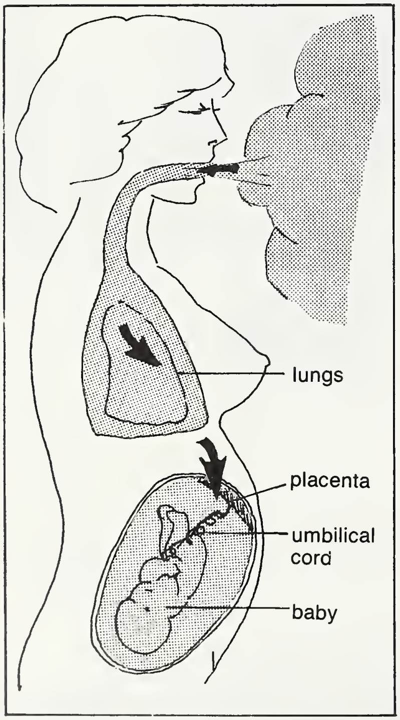
Carbon monoxide works by depriving the body of oxygen it needs. The red blood cells which normally carry oxygen from the lungs to all of the body's tissues, will choose carbon monoxide first should it be present in the lungs. As the carbon monoxide content of the blood increases, more and more of the body begins to starve for oxygen, including heart and brain tissues. As a result, a person may become somewhat indecisive and the ability to sort out visual detail may suffer. In addition, carbon monoxide is a cumulative poison. That is, each successive cigarette smoked in your presence adds to the carbon monoxide buildup.

Sidestream smoke causes significant damage to the lungs of nonsmokers exposed to it. The smoke from a cigarette permanently scars some of the small airways in the lungs. As this reduces lung capacity, it makes it necessary to put more effort into breathing in order to get the amount of oxygen a body needs. Furthermore, reduced lung capacity is often a forerunner of emphysema and other serious lung disorders.

In addition to the carbon monoxide content and the lung damage, sidestream smoke contains a large number of carcinogens. The risk of cancer increases along with the amount of exposure to any carcinogen. Carcinogens can be deceptive. Some seem to lodge in the body and lie dormant for years before producing a cancer.

When it comes to tobacco smoke, the only dose considered safe is no dose at all. If you continually breathe sidestream smoke from others' cigarettes you are getting tiny doses day after day.

Smoking and Pregnancy



When a pregnant woman smokes, it can have harmful effects on her unborn child. **Cigarettes are drugs.** Nicotine and carbon monoxide inhaled in cigarette smoke enter the mother's bloodstream, cross the placenta barrier and enter the baby's bloodstream.

Normal weight gain and development of the baby depend on a good supply of oxygen from the mother. Nicotine and carbon monoxide cut down the oxygen supply to the baby, potentially reducing its birthweight.

Carbon monoxide and nicotine operate in the following ways:

1. Carbon monoxide in the mother's blood can reduce the baby's oxygen supply up to 40%. The level of carbon monoxide in the baby's blood is directly related to the number of cigarettes smoked by the mother. Studies show that there may be even more carbon monoxide in the blood of the unborn baby than in the blood of the smoking mother.

2. Nicotine causes narrowing of the blood vessels in the placenta, further reducing the supply of food and oxygen to the unborn baby. It also reduces the movements of certain chest muscles experienced by the baby as it ''practices'' to prepare for breathing after birth.

When women smoke while pregnant, a number of complications may result, as indicated by the following statistics:

1. The risk of miscarriage among smoking women is almost double that of non-smoking women. The chances of having a premature delivery are much higher among women who smoke.
2. There is a 4 times greater risk of early separation of the placenta, possibly due to the narrow blood vessels and restricted blood supply to the cells around the edges of the placenta. This condition is the second leading cause of stillbirth and newborn deaths in Canada.
3. There is a 28% greater risk of stillbirths and deaths during the first week of life among babies of smoking mothers.
4. Babies of smokers weigh an average of 225 gm (8 oz) less than those of non-smokers and are often correspondingly underdeveloped. Women who quit smoking before the fourth month of pregnancy have babies with birthweights closer to those of non-smoking mothers.

Effects of Parents' Smoke On Their Children's Health

Babies of parents who smoke are more prone to pneumonia and bronchitis in their first year of life. Even after that point, children of smokers experience more respiratory illnesses, if they suffer from asthma or allergies. This is probably because they are breathing in irritants from their parents' cigarette smoke, often in enclosed rooms.

The smoke from the burning end of a cigarette is filled with hundreds of chemicals. There is actually more tar and nicotine in this sidestream smoke than in the smoke inhaled directly from the cigarette. Small amounts of nicotine get into the breast milk of smoking mothers. A full day of nursing, combined with the external nicotine intake, is likely to cause irritability and poor sleeping habits in an infant. In addition, accumulated smoke in an enclosed area significantly increases the carbon monoxide level in a child's blood, and thus increases the child's heart rate and blood pressure.

Children whose parents smoke are more likely to become smokers themselves as a result of their parents' example. If parents stop smoking, this tendency as well as the above mentioned effects, can largely be prevented.

Advertising and Smoking

Effective advertising is a powerful means of influencing the public mind. Advertisements have the power to influence far beyond presenting appealing images of smoking. Some of the influences can be very subtle with the person totally unaware of the influence. Below is a list of some of the techniques used in advertising, as well as their intent to influence the reader.

1. Package of cigarettes is fully open.
   - several cigarettes pulled out, as if to offer one to reader. Encourages you to want one.

2. Cigarette package is larger and more prominent than other objects in the advertisement.
   - focuses your attention on the cigarette package

3. People in the advertisement are good looking and having a good time.
   - people who enjoy a glamorous and romantic lifestyle smoke this brand of cigarette. Implication: if you buy these cigarettes you'll be like these people.

4. Activities depicted are healthy outdoor activities with healthy good looking models.
   - smoking becomes associated with healthful activities.

5. Photography is elaborate and expensive.
   - an attractive photograph will attract you to their product

6. Rarely are the people smoking in a cigarette advertisement. If they are, no smoke is shown even though the cigarette is visibly lit.
   - the reality of air pollution would spoil the advertisement's glamorous image

7. The only choice offered is between brands, not whether one should use this product at all.
   - you will prefer their brand, even though experts indicate that it is difficult to tell one brand from another.

8. The required warning is in small type and placed outside the main focus of the advertisement.
   - not likely to be noticed
   - will not interfere with the message of the advertisement

---

* The preceding information on smoking is courtesy of the Canadian Cancer Society. For further information on smoking and ways to stop smoking, please contact the above agency.

Exercise 1

Part One: Fill in the blanks.

1. Complete each of the following statements by filling in the numbered blank on the right.

(a) Substances capable of producing cancer are __(1)__ .

(b) A substance in tobacco that leads to addiction of tobacco is __(2)__ .

(c) A tumor that develops at one site is __(3)__ as compared to a __(4)__ tumor that develops and spreads to other areas.

(d) __(5)__ are cleansing structures in the lung.

(e) The risk of lung cancer __(6)__ with the total amount of exposure to cigarettes.

(f) Once the cilia are no longer able to remove impurities from the lungs, __(7)__ is the only cleansing method left.

(1) ____________________

(2) ____________________

(3) ____________________

(4) ____________________

(5) ____________________

(6) ____________________

(7) ____________________

Part Two: Short Answer

1. Distinguish between ''mainstream'' pollution and ''sidestream'' pollution.

____

____

____

____

____

2. List 5 effects of sidestream pollution on a non-smoker.

(a) ______________________________________

(b) ______________________________________

(c) ______________________________________

(d) ______________________________________

(e) ______________________________________

3. List 5 ways in which smoking can affect fetal development.

(a) ____________________

(b) ____________________

(c) ____________________

(d) ____________________

(e) ____________________

4. List the two ways in which cigarette smoking causes or contributes to lung cancer.

Please check your answers with those given on page 16.

Alcohol

READ

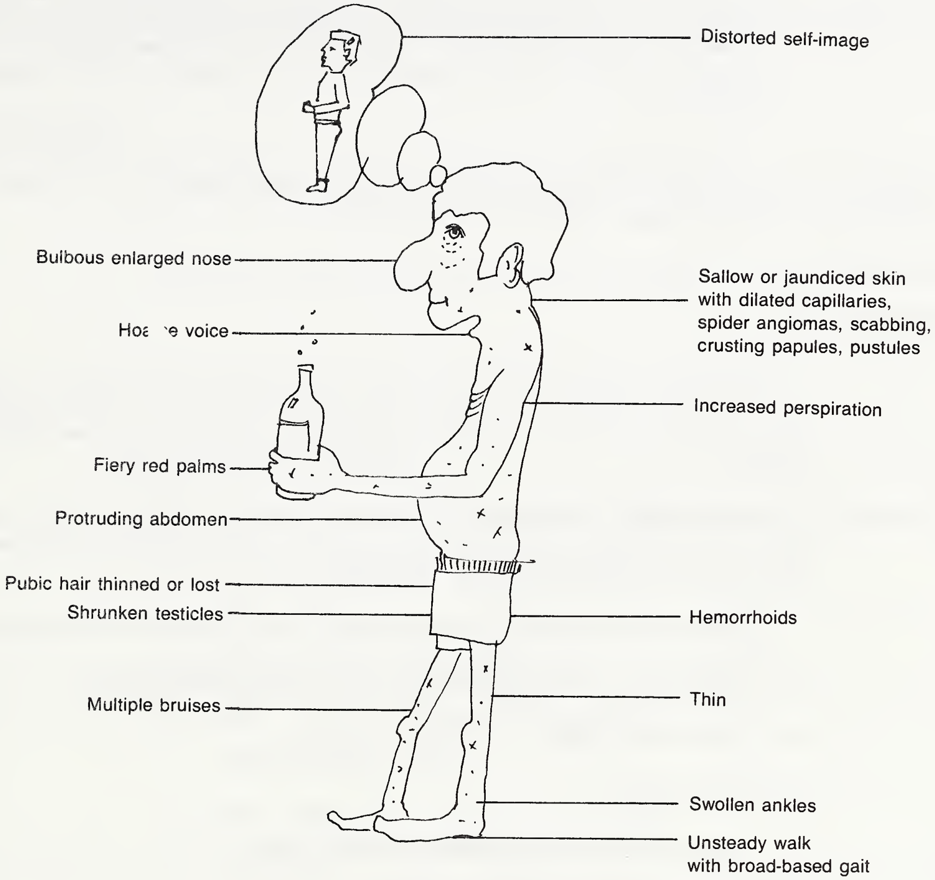
Read the section entitled "Alcohol and the Human Body" in your textbook. (pages 312-313)

The active ingredient in alcoholic beverages is ethyl alcohol or ethanol (C_2H_5OH). Alcohol is the most widely used depressant drug. It alters the functioning of the brain and nervous system. The diagram on page 313 of your textbook illustrates the effects of alcohol on the brain.

At first the use of alcohol leads one to believe it is a stimulant as it decreases inhibitions and gives the user the feeling of a stimulant or a "high". As the amount of alcohol consumed increases so do its effects as a depressant. This results in physical changes: decreased dexterity, impaired vision and speech, loss of coordination and balance. In some cases, extreme amounts can lead to death as the alcohol depresses the medulla oblongata and the user stops breathing.

Abusers of alcohol or chronic users can incur many medical complications. The prolonged intake of alcohol results in physical changes, including a change in eating habits.

The following diagram illustrates some of these physical changes and the altered perception the alcoholic has of himself.



Internally, drastic changes occur. The gastrointestinal tract is affected in the following ways.

(1) Alcohol stimulates the secretion of HCl (hydrochloric acid) in the stomach and irritates the intestinal lining. Peristalsis is affected. Ulcers can be caused by the chronic use of alcohol. Gastrointestinal bleeding may occur. As a result of these changes heavy drinkers often experience appetite loss, belching, nausea, vomiting, constipation and diarrhea.

(2) The pancreas is also affected. Since this organ is a major site of enzyme secretions, if inflammed the digestive secretions will not readily be released. Insulin secretion by islets of Langerhans, located in the pancreas, is also affected. Prolonged abuse of alcohol could result in diabetes.

(3) The liver is an essential organ. In addition to manufacturing clotting agents, storing vitamins, producing digestive enzymes and regulating the blood sugar level, the liver also breaks down wastes and poisons. The liver enzyme, alcohol dehydrogenase, initiates the breakdown of alcohol.

In the presence of alcohol, the liver abandons other normal and needed functions to concentrate on alcohol breakdown. The most serious condition of liver damage due to alcohol is cirrhosis of the liver. This condition results from destruction of liver cells being replaced by nonfunctioning scar tissue. A complication of this disease is cancer of the liver.

The damages of alcohol to the body do not end here but manifest themselves in all body functions and organ systems. For more information on damages caused by alcohol contact AADAC - Library Branch.

Fetal Alcohol Syndrome

Fetal alcohol syndrome (FAS) is a condition caused by prenatal exposure to ethanol. The results of alcohol on the fetus are visible in the physical characteristics of the newborn. Mental changes also occur. These alterations in physical appearance and mental abilities vary in intensity.

Alcohol passes from the mother to the fetus through the placenta. The concentration and amount of alcohol consumed by the mother becomes that of the fetus. The most alarming result of FAS in children is mental retardation.

The basic characteristics of the Fetal Alcohol Syndrome (FAS) can be summarized as:

(1) growth and development retarded - both prenatal and postnatal

(2) reduced size of skull

(3) short eye slits

(4) vertical folds of skin on either side of the nose

(5) incomplete development of upper jaw

(6) cleft palate

(7) smallness of jaws

(8) joint abnormalities

(9) heart deformities

(10) altered pattern of grooves in palm

(11) fine motor dysfunction

(12) irregular genitalia

(13) areas of pink to dark blue-red skin

Unfortunately, the fetal alcohol syndrome is now the third leading disorder in which mental retardation is one of the characteristics. The intensity of physical changes and mental retardation that occurs as a result of FAS varies with the amount and exposure to alcohol. Medically, the avoidance of alcohol during pregnancy is now stressed.

Therefore, the abuse of alcohol affects not only the user but also the unborn child.

Drinking and Driving

Alcohol abuse is also linked to traffic violations and the death of innocent people by drunk drivers. Read page 313 of your textbook regarding alcohol and traffic violations.

For further information on alcohol abuse and its effects on society, please contact AADAC.

Exercise 2

Part One: Fill in the blanks.

1. Complete each of the following statements by filling in the numbered blank on the right.

   (a) The active ingredient in alcoholic beverages is ___(1)___ .

   (b) Alcohol is a ___(2)___ drug.

   (c) The ___(3)___ is the organ responsible for breaking down alcohol.

   (d) The condition in which liver cells are destroyed and replaced by non-functioning scar tissue is ___(4)___ of the liver.

   (e) ___(5)___ is caused by prenatal exposure to alcohol.

(1) ____________________

(2) ____________________

(3) ____________________

(4) ____________________

(5) ____________________

Part Two: Short Answer

1. List 3 physical changes that occur from consuming too much alcohol.

   (a) ____

   (b) ____

   (c) ____

2. List 5 physical characteristics a FAS child may exhibit.

(a) ______________________________

(b) ______________________________

(c) ______________________________

(d) ______________________________

(e) ______________________________

3. How can alcohol cause the death of an individual?

____

____

____

____

Please check your answers with those given on pages 16 and 17.

Drugs

Drugs, and the chemicals they contain, alter the nervous system and lead to changes in behavior and awareness. Categorized either as medical or nonmedical, drugs can be divided into three groups with respect to the psychological and behavioral changes they elicit. These are stimulants, depressants, and hallucinogens.

Read the section "Chemicals and the Nervous System" in your text (pages 163 - 169). Know the differences between the three drug groups and become familiar with the drug guide on pages 166 - 169.

Exercise 3

1. Distinguish between stimulants, depressants and hallucinogens based on their effect on the body systems.

Stimulants - ______________________________

____

____

Depressants - ____________________

____

____

Hallucinogens - ____________________

____

____

2. List 5 examples of stimulants.

(a) ____________________

(b) ____________________

(c) ____________________

(d) ____________________

(e) ____________________

3. List 3 examples of depressants.

(a) ____________________

(b) ____________________

(c) ____________________

4. State 2 short-term effects of marijuana.

(a) ____________________

(b) ____________________

5. List 4 drugs that will produce death if taken in large amounts.

(a) ____________________

(b) ____________________

(c) ____________________

(d) ____________________

Please check your answers with those given on page 17.

ANSWERS TO KEYED EXERCISES

Exercise 1, pp. 9 - 10.

Part One: Fill-in-the-blanks

1. Complete the statements with the words given below.

(1)	**carcinogens**	(5)	**cilia**
(2)	**nicotine**	(6)	**increases**
(3)	**benign**	(7)	**coughing**
(4)	**malignant**		

Part Two: Short Answer

1. Mainstream pollution - **smoke that is inhaled and then exhaled by a smoker**

   Sidestream pollution - **smoke not inhaled by the smoker eg. smoke from a burning cigarette.**

2. (a) **eye irritation**
   (b) **if allergic to certain substances that affect the respiratory system, smoke can irritate nasal passages resulting in coughing and a runny nose.**
   (c) **headaches**
   (d) **damage to lungs**
   (e) **increases carbon monoxide content of the body**

3. (a) **nicotine and carbon monoxide reduce oxygen supply**
   (b) **reduce the supply of nutrients**
   (c) **inhibit breathing motions of fetus**
   (d) **babies tend to be smaller**
   (e) **increases chances of miscarriage**

4. **Cigarette smoke inhibits cleansing action of cilia in the lungs allowing the body system to be more susceptible to other carcinogens eg. coal tars.**

Exercise 2, pp. 13 - 14.

Part One: Fill-in-the-blanks.

1. Complete the statements with the words given below.

(1)	**ethanol**	(4)	**cirrhosis**
(2)	**depressant**	(5)	**FAS (Fetal Alcohol Syndrome)**
(3)	**liver**		

Part Two: Short Answer

1. (a) **decreased dexterity**
   (b) **impaired vision and speech**
   (c) **loss of coordination and balance**

2. (a) **reduced skull size**
   (b) **smallness of jaws**
   (c) **narrow eye slits**
   (d) **vertical folds of skin on sides of nose**
   (e) **cleft palate**
   - for more characteristics see p. 12

3. **Large amounts of alcohol depress the medulla oblongata and breathing ceases.**

Exercise 3, pp. 14 - 15.

1. Stimulants - **stimulate the sympathetic nervous system, eg. increase heart rate**

   Depressants - **reduce the active functions of the brain and nervous system**

   Hallucinogens - **distort visual and auditory senses; can produce hallucinations**

2. (a) **coffee**
   (b) **tea**
   (c) **cola**
   (d) **tobacco**
   (e) **amphetamines**

3. (a) **alcohol**
   (b) **tranquilizers and barbituates**
   (c) **opiates**

4. (a) **a "high"**
   (b) **increased pulse rate (see text p. 167)**

5. (a) **alcohol**
   (b) **sedative hypnotics**
   (c) **PCP - "Angel Dust"**
   (d) **opiates - heroin**

EXERCISES TO BE SENT IN FOR CORRECTION

Part One: True or False Questions

Indicate whether the following statements are True or False by circling the correct letter at the beginning of each statement.

T F 1. 90% of lung cancer is related to carcinogens such as asbestos and coal tar.

T F 2. Smoking is a contributor to cardiovascular disease.

T F 3. Once smoking is stopped the lungs can be restored to a healthy state.

T F 4. The depth of inhalation of smoke from cigarettes does not increase the risk of lung cancer.

T F 5. A smoker acts as a filter reducing the amount of sidestream pollution that will affect a non-smoker.

T F 6. Carbon monoxide robs the body of oxygen needed as it incapacitates the white blood cells.

T F 7. Carbon monoxide is a cumulative poison in that it disappears easily once it enters the blood stream.

T F 8. Carcinogens are immediate acting.

T F 9. If you smoke chances are your children will also smoke.

T F 10. The risk of a miscarriage for a smoking woman is twice that of a non-smoker.

T F 11. If a person was to stop smoking, their chances for lung cancer would be highly decreased.

T F 12. The amount of alcohol a mother consumes is equal to the amount that affects the fetus.

T F 13. The intensity of the FAS in a child varies with each child.

T F 14. Alcohol, a self-inflicted drug, only affects the user.

T F 15. Alcohol is a major factor in a large number of traffic accidents.

T F 16. A pregnant woman should not consume alcohol.

T F 17. In the presence of alcohol, the pancreas abandons all necessary functions to break down alcohol.

T F 18. Alcohol can cause ulcers, irritating the stomach and intestinal lining.

T F 19. The prolonged use of alcohol can result in diabetes as the liver is affected.

T F 20. The use of marijuana increases the risk of lung cancer.

T F 21. All depressants affect individuals in the same manner.

Part Two: Matching and Fill-in-the-Blanks

1. Match the following by writing the letter of the item described in column II in the blank beside each statement in column I. Use any letter more than once, if necessary.

   State which areas of the brain are responsible for the following changes due to alcohol intake.

	Column I	Column II
______	difficulty walking	A. Parietal Lobe
______	double vision may occur	B. Occipital Lobe
______	removal of inhibitions	C. Cerebellum
______	incapable of maintaining balance	D. Frontal Lobe
______	can lead to death due to decrease of senses and body functions	E. Thalmus and Medulla
______	slurred speech	

2. Complete each of the following statements by filling in the numbered blank on the right.

(a) The ___(1)___ system is affected by the use of medical and non-medical drugs.

(b) Some athletes, in competition, may use ___(2)___ to increase body energy.

(c) ___(3)___ often duplicate the effects of alcohol in the body.

(d) The ___(4)___ and ___(5)___ combination is often the cause of accidental suicides.

(e) An example of a highly addictive and effective pain killer is ___(6)___ .

(f) Two stimulants used by people daily are ___(7)___ and ___(8)___ .

(g) Molecular mimicry of drugs occurs in the use of ___(9)___ drugs. An example of this is ___(10)___ replacing ___(11)___ which is located in the brain.

(h) Substances acting as effective pain killers are ___(12)___ .

(i) Effects of the sympathetic nervous system are duplicated by ___(13)___ which functions similar to adrenaline.

(1) ____________________

(2) ____________________

(3) ____________________

(4) ____________________

(5) ____________________

(6) ____________________

(7) ____________________

(8) ____________________

(9) ____________________

(10) ____________________

(11) ____________________

(12) ____________________

(13) ____________________

(j) Upon alcohol withdrawal a user may experience convulsions and ___ (14) ___ . (two words)

(k) The major type of cancer produced by smoking is ___(15)___ cancer.

(l) Alcohol passes from the mother to the fetus through the ___(16)___ .

(m) The most alarming result of FAS in children is ___ (17) ___ . (two words)

(n) The extent of the damage of FAS in a child varies with the ___(18)___ and ___(19)___ to alcohol.

(o) The ___(20)___ ___(20)___ is used to test suspected impaired drivers.

(p) Impaired driving charges are laid if a driver has ___(21)___ alcohol concentration.

(14) ____________

(15) ____________

(16) ____________

(17) ____________

(18) ____________

(19) ____________

(20) ____________

____

(21) ____________

Part Three: Short Answer Questions

1. Explain how smoking can lead to stillbirths and newborn deaths.

2. Why is carbon monoxide dangerous to the body system?

3. Obtain a cigarette advertisement and include it with this question. Explain how the advertising media glorifies smoking. Specifically describe four techniques used by the advertiser to influence the viewer.

Fold, if necessary, and attach your advertisement below.

4. Explain why alcohol affects the liver so drastically.

Please submit pages 18 to 22 for correction.

END OF LESSON 19

LESSON RECORD FORM

3230 Biology 30
Revised 03/89

FOR STUDENT USE ONLY

Date Lesson Submitted

Time Spent on Lesson

(If label is missing
or incorrect)

File Number

Lesson Number ______

FOR SCHOOL USE ONLY

Assigned
Teacher: ______

Lesson Grading: ______

Additional Grading
E/R/P Code: ______

Mark: ______

Graded by: ______

Assignment Code: ______

Date Lesson Received:

Lesson Recorded ______

Student's Questions and Comments

Apply Lesson Label Here

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Please verify that preprinted label is for correct course and lesson.

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Correspondence Teacher

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ALBERTA CORRESPONDENCE SCHOOL

MAILING INSTRUCTIONS FOR CORRESPONDENCE LESSONS

1. BEFORE MAILING YOUR LESSONS, PLEASE SEE THAT:

(1) All pages are numbered and in order, and no paper clips or staples are used.
(2) All exercises are completed. If not, explain why.
(3) Your work has been re-read to ensure accuracy in spelling and lesson details.
(4) The Lesson Record Form is filled out and the correct lesson label is attached.
(5) This mailing sheet is placed on the lesson.

2. POSTAGE REGULATIONS

Do **not** enclose letters with lessons.

Send all letters in a separate envelope.

3. POSTAGE RATES

First Class

Take your lesson to the Post Office and have it weighed. Attach sufficient postage and a **green first-class sticker to the front of the envelope, and seal the envelope. Correspondence lessons will travel faster if first-class postage is used.**

Try to mail each lesson as soon as it has been completed.

When you register for correspondence courses, you are expected to send lessons for correction regularly. Avoid sending more than two or three lessons in one subject at the same time.

OBJECTIVES

Upon completion of Lesson 20, the student should be able to:

1. **Define** pollution.
2. **Recognize** pollutants of air, water and soil.
3. **Understand** how air quality is measured in Alberta.
4. **Know** the major air pollutants of individual cities - Calgary and Edmonton.
5. **Know** the 5 indexes air pollution readings are based on in Alberta.
6. **Understand** the ''greenhouse effect''.
7. **Know** the medical damages of the four types of pollution.
8. **Define** acid rain.
9. **Understand** the formation of acid rain.
10. **Understand** that usable water is a limited commodity.
11. **Know** why water is a versatile compound.
12. **Recognize** the effects of misuse of chemicals.
13. **Know** the methods used to deposit solid wastes.
14. **Understand** the workings of a landfill.
15. **Know** how radioactive and hazardous wastes are handled in Alberta.
16. **Understand** the ''ripple effect'' of persistant use of pesticides.
17. **Recognize** noise pollution as a valid form of pollution.
18. **Know** the extent to which an individual contributes to, as well as helps reduce, the effects of pollution.

POLLUTION

Introduction

Pollution! Increasing concern about threats to our environment has been centered around a number of adverse conditions which in one way or another combine to deteriorate the quality of life on the planet Earth. These conditions have all been categorized under the all-inclusive term, pollution.

Pollution is like the weather in that everyone talks about it but differs in that people rarely think or do anything about it until it affects them adversely - until it is almost too late. Unlike the weather which one individual cannot control or change, pollution and its results can be altered by the individual. The individual with knowledge and concern can begin to become part of a solution to a problem that threatens the environment and, in turn, human existence.

Therefore, the intent of this lesson is to attempt to define pollution, state the various types of pollution and establish the facts about pollution. Students will then be encouraged to seriously consider present and future consequences of continued pollution and the abuse of our natural resources such as water and air. As an individual or a group, students should consider what they can do to control pollution.

What is Pollution?

Pollution takes on many forms and yet is not always identifiable. The meaning of pollution varies from individual to individual and even more so when large groups are concerned.

Basically, pollution as defined in the *Pollution Reader*, ''The Phenomenon of Pollution'' by H.P. and Blanche Van Ginkle is ''The addition of foreign matter to the natural environment to a degree which is insupportable by nature.''

The same term as defined by the Meteorological Branch of the Department of Transport Canada relates it directly to people. Pollution is ''any material in the air that causes man discomfort, interferes with his health or damages his property.''

To others pollution is simply contamination.

There are many ways of expressing a description of pollution. The important point that all definitions have in common is that they describe pollution as being harmful to the environment and to people.

If we consider pollution to be the addition of contaminants to the environment in such quantity that go beyond natural tolerances and that the natural processes of restoration are inhibited, perhaps causes and effects should be considered. For example, one person using laundry detergent is not likely to contribute an intolerable amount of contaminants to the environment. Would the effect be the same if 100 000 persons in a restricted area such as a city each used an amount equal to that of the individual? One car in an area produces a tolerable amount of air and noise pollution. Would the effect be the same if 100 000 cars were used more or less at the same time in a large city? One cigarette smoked in a room produces a small amount of contamination. Is the effect the same when many cigarettes are smoked simultaneously and continually? Public opinion has a great influence on standards set for pollution control. If there is a high level of public support then standards of control will likely be high and adhered to. Low levels of public support would generate the opposite effect. The recognition of cause and effect of pollution is important if control is to be achieved.

There are no simple solutions to pollution control problems. Pollution of the environment has increased rapidly due to higher population densities throughout the world and the nature of the waste material, much of which is not biodegradable, (e.g. plastics, tin foil). Effective control must be brought about. Attitudes must change; techniques and guidelines must be developed and used. One thing is certain however, pollution is everyone's concern and everyone's responsibility. Pollution control must be practiced by every individual citizen as well as by industries and governments.

Environmental pollution has gained recognition as a serious problem. Ever since human beings began to inhabit the earth, they have brought about changes, some harmless to the environment and some that are very harmful. Advanced technology is speeding up the contamination of the environment with gases, acids, metals, radioactive materials and poisons which are damaging to health. Contaminations and alterations of the environment take place. High levels of noise, trash and garbage are created. The environment, like people, has limitations to the abuse it can tolerate.

If we are to extend our programs to control pollution of the environment, one of the first things we must determine is why and how we contribute to pollution of our surroundings. Our attitudes and the relationship between ourselves and nature must be considered.

In this lesson, four major types of pollution will be considered - air, water, land and noise.

Air Pollution

Air is a mixture of a number of gases. Nitrogen and oxygen make up about 99% of the layer of gaseous matter surrounding the earth called the atmosphere. Carbon dioxide and a few other gases make up the rest. Air also includes water vapor, but the amount varies constantly. At any given time, air may also contain contaminants produced by natural processes such as volcanic action, forest fires, dust storms and decaying vegetation.

The atmosphere forms a continuous layer around the earth and extends out from the surface for distances of 400 km to 1440 km. About 95% of the total air mass is concentrated in a relatively thin layer near the surface of the earth. (The atmosphere becomes less dense until it finally merges into space.) This thin layer, known as the troposphere, varies in thickness from about 8 km at the poles to approximately 17 km at the equator. This layer is important because our weather is created within it. More important, it contains the mixture of gases upon which life on the planet Earth depends. Animal and plant life are dependent upon oxygen. Plants are also dependent upon carbon dioxide. Temperature control and precipitation are also influenced by the troposphere.

The air around us carries many particles and gases from natural sources such as bacteria, spores, pollen, meteoric and volcanic dust, soil dust, sodium chloride from ocean spray, and ozone and nitrogen dioxide which are created by lightning. These are products of natural processes and under normal conditions nature can disperse these materials. Because air is fluid, these agents are able to be moved around in the atmosphere where their concentrations are reduced. Rain, snow and dew help to wash the air by removing dust and smoke particles, and by dissolving some of the gases such as nitrogen dioxide. Some of the other gases are absorbed by plants, soil and water. Under normal natural conditions, the removal of these natural contaminants is in balance with their production, therefore the air remains relatively clean. Pollution occurs when the balance is upset by contaminants being added to the air faster than they can be removed.

The major polluters of the air can be placed into two categories - the individual citizen and industry.

Pollution enters the atmosphere in three basic ways:

1. Friction (substances rubbing together) causing the release of contaminating particles.
2. Vaporization from industrial processes involving high heat.
3. Combustion of organic compounds such as fossil fuels.

A study of air quality, pollution and its contributers has been made by Alberta Environment in a publication ''IQUA, An Air Quality Index for Alberta''. The following is an excerpt from the publication.

IQUA is a new way of letting the public know about air quality in simple and concise terms. It was developed by a federal-provincial committee in 1978 and introduced in Alberta by the Pollution Control Division of Alberta Environment in December, 1979.

IQUA converts the measurements of five major pollutants to a single number and matching description. A rating of 0-25 indicates Good air quality, 26-50 is Fair, 51-100 is Poor and more than 100 is Very Poor.

The four descriptions are linked to regulations under Alberta's Clean Air Act and the National Air Quality Objectives. These regulations and objectives consider the effects of different pollutants on human health, animals, vegetation or general concerns such as odor and visibility. The Alberta regulations reflect levels where little or no effects are known to occur with even the most sensitive receptor, whether that be humans, animals, vegetation or materials.

One of IQUA's many strong points is that it relates the effects of different pollutants to a common scale. At an IQUA of 60 (Poor), for example, each pollutant will have the same degree of environmental effect. The specific effects themselves, however, will vary according to the pollutant.

IQUA is calculated by Alberta Environment in Calgary and Edmonton twice each weekday. When the index rises above 50, it is issued more frequently until it falls below 50. The index is based on readings for five major pollutants, which are measured at three monitoring stations in each city.

The stations are located in the downtown, industrial and residential areas, and a separate IQUA is prepared at each station to give the public specific information about air quality in three areas of the city.

The index is based on reading for sulphur dioxide (SO_2), ozone (O_3), carbon monoxide (CO), suspended particulated matter (COH) and nitrogen dioxide (NO_2). Each reading is converted to an IQUA number, and the highest number becomes the index for the individual station.

By reporting a number for the highest pollutant out of the five measured, IQUA provides a more specific picture of air quality than an index that averages all the readings.

The Major Air Pollutants

Carbon Monoxide (CO): A colorless, odorless, tasteless gas produced by the incomplete combustion of fuel, particularly in motor vehicles. Pure gasoline burned yields carbon dioxide and water. Gasoline is not pure but a concoction of hydrocarbons and additives to assure ''total performance'' in your car's engine.

Gasoline consists of three kinds of hydrocarbons:

Paraffin	burns well at low speeds
Olefin	
Aromatics	burns well at high speeds

PLUS

Tetraethyl lead	to prevent paraffin explosion before ignition and eliminate engine knock
Ethylene dichloride	to prevent lead buildup on plugs and valves
Antioxidants	
Metal deactivators	
Anti-rust compounds	
Anti-icing compounds	
Detergents	
Lubricants	

Thus, gasoline burned, yields NO_2, CO_2, CO and hydrocarbons. These emissions are a result of unburned fuel, poor ignition system condition, too rich or too lean fuel-air mixture, low operating temperatures or valve problems. To provide more efficient use of fuel and decrease emissions to the atmosphere, manufacturers have redesigned engines and installed electronic ignition, catalytic converters, heated intake air, and carbon canisters. The use of unleaded gas, propane and diesel also reduce CO emission.

CO replaces oxygen in the red blood cells, reducing the amount of oxygen that can reach the body cells and maintain life. Lack of oxygen affects the brain, and the first symptoms are impaired perception and thinking. At elevated levels this can aggravate the condition of people with chronic heart and respiratory disease.

Ozone (O_3): A pungent, colorless gas that forms in the air as a result of the sun's photochemical action on hydrocarbons and oxides of nitrogen, such as those released by automobiles. Ozone also occurs naturally at levels not much lower than those known to be toxic, particularly in areas of high elevation. High levels of ozone by itself or in combination with other substances can cause eye irritation, breathing difficulty, vegetation damage and decreased visibility.

Nitrogen Oxides (NO): Nitrogen oxide is a relatively non-toxic gas formed mainly in combustion processes where nitrogen and oxygen combine under extremely high temperatures. However, nitrogen oxide converts readily in the atmosphere to nitrogen dioxide (NO_2), a much more toxic, irritating gas that can in the long term combine with water to form acids. It also contributes to the formation of ozone and photochemical smog. Nitrogen oxides can affect health, suppress growth of vegetation, corrode metals and reduce visibility. It is a contributor to acid rain.

Particulates: Particulates are tiny particles of solid or liquid matter that tend to remain suspended in the air such as mist, dust, aerosols, smoke and soot. When these fine particles enter the respiratory system, people with respiratory ailments may experience difficulty in breathing. Particulates can also decrease visibility.

Sulphur Dioxide (SO_2): Sulphur dioxide is a colorless, pungent gas which smells like burnt matches. It is formed when sulphur and oxygen combine, usually as a result of burning fuels containing sulphur or as a by-product resulting from the removal of sulphur from natural gas and crude oil. The gas combines with water to form acids that can corrode metals, irritate the eyes and lungs and damage vegetation. It is a contributor to acid rain.

Air Quality: Calgary and Edmonton

Air quality has been monitored in Calgary and Edmonton for about 20 years. IQUA is a new way of reporting this air quality information to the public.

In both cities, air quality is Good (0-25) almost all the time. The index occasionally reaches into the Fair range (26-50) in each city. When this happens, it can be due to several reasons: an increase in emissions (for example, during rush hours), and/or a buildup of air pollutants during certain meteorological conditions, such as an inversion.

An inversion occurs whenever a layer of warm air, such as a prairie chinook wind, moves in and temporarily traps pollutants in a pocket of cooler, heavier air over the city. An inversion can also occur in a valley or basin-shaped area until the cool, low-lying morning air warms and rises.

Because of its topography and weather, Calgary will generally record more Fair ratings than Edmonton, even though Edmonton has more than twice the total emissions of Calgary. An inventory of emissions, for example, showed that total yearly emissions in Edmonton in 1973 amounted to about 420 000 tonnes, compared with Calgary's 169 000 tonnes.

In Edmonton, 58 per cent of total emissions comes from industry and 38 per cent from motor vehicles. In Calgary, this situation is reversed: 10 per cent of emissions comes from industry and 83 per cent from motor vehicles.

Air quality in both cities will very seldom reach the Poor (51-100) level, and the frequency of a Very Poor index is extremely low. At these elevated levels, it would be wise for people with respiratory or cardiac problems to avoid unnecessary strain.

Recurring Very Poor ratings of long duration indicate that long term control action is needed to avoid reaching conditions that might provide long term risks to public health and environmental quality.

	IQUA Description	Frequency in Alberta	Effects
0	**0-25 GOOD**	Almost all the time	IQUA levels in this range indicate that there is no effect on any receptor, including humans, animals, vegetation and materials. The long term goal for air quality in Canada is to be in this range all the time.
25	**26-50 FAIR**	Occasional (usually when weather conditions cause emissions to build up.)	When IQUA levels are in this range, there is adequate protection against effects on soil, water, vegetation, materials, animals, visibility, personal comfort and well-being. IQUA levels should seldom exceed this range in all parts of Canada.
50	**51-100 POOR**	Very Seldom	IQUA levels in this range indicate that not all aspects of the environment are adequately protected from possible adverse effects. Long term control action may be necessary, depending on the frequency, duration and circumstances of the readings.
100 100 +	**101 + VERY POOR**	Very Rare	At this range, further deterioration of air quality and continued high readings could pose a risk to public health or endanger the prevailing lifestyle.

Figure 1: Air Quality Measurement and Description

Effects of Industrial and Automotive Pollution

1. A direct result of the gasoline pollutants plus sulphur dioxide from industry is the creation of photochemical smog. An increase in smog is accompanied by a decrease in sunlight and visibility.

2. A buildup of CO_2 results in the ''greenhouse effect.'' Light energy radiating from the sun is absorbed by the earth and re-radiated as heat energy. Due to the presence of water vapour in the air, and to a lesser degree, the carbon-dioxide and ozone, the atmosphere can and does absorb heat energy. The greenhouse effect is a phenomenon where the air acts like a glass in a greenhouse allowing the light to pass through but holding back the re-radiated heat.

3. Directly affecting each individual is the increased buildup of carbon monoxide which has an affinity for hemoglobin and results in the body supplying less oxygen for respiration. The body can tolerate 10 parts per million (ppm) CO but the maximum allowed before decreased sensitivity to the surrounding, lack of energy and endurance occur is 30 ppm. The average smoker is already at this level and a heavy smoker is subjected to a danger level when he breathes air containing 30 ppm. However, the risk of danger to one's health increases due to automobile emissions. Cars stopped at a light can increase the CO content of the atmosphere to 370 ppm.

4. Studies indicate that an increase in pollution results in an increase in respiratory diseases. There are four particular diseases that fall into this category.

(a)	Bronchitis:	Caused by permanent damage of bronchial tubes decreasing ciliary action while increasing mucus production. Condition results in chronic cough, mucus buildup and shortness of breath.
(b)	Bronchial Asthma:	Reaction of membranes to foreign material causing membranes to swell. Results in difficult expulsion of air, wheezing and shortness of breath.
(c)	Emphysema:	Due to constriction of bronchioles, inhalation and exhalation of air sacs often cause sacs in lungs to swell and burst. Air sacs then unite resulting in a decrease of capillaries for oxygen intake. The result decreases the oxygen capacity affecting the body and causing chronic shortness of breath.
(d)	Lung Cancer:	This is a direct result of carcinogens such as benzpyrene which is associated with coal smoke and cigarette tars inhaled by the smoker in which cilia action is inhibited by pollutants.

Acid Rain

Normally, rainfall is somewhat acidic because of carbon dioxide naturally present in the atmosphere. Industrial pollutants and particles in the atmosphere can make rainfall more acidic than normal, resulting in what is termed acid rain.

Acid rain causes chemical changes in soils and water bodies. Over a long term, these changes can reduce soil fertility and kill fish and plant life in lakes. In northern Ontario, at least 200 lakes have been robbed of life by acid rain. Increased acidity may also cause secondary chemical reactions that release toxic compounds in soil and water.

Rainfall monitoring and sampling confirm that precipitation is up to 10 times more acidic than normal over almost all of Eastern Canada. However, over most of Western Canada, rainfall readings are normal or even less acidic than is usual for clean rain.

Three elements are necessary for acid rain to become a serious problem:

(a) pollutant sources (usually large industrial or urban areas)

(b) meteorological conditions that transport pollutants and allow acid rain to form

(c) an environment sensitive to acid rain.

For all three elements there are significant differences between Western and Eastern Canada.

1. **Pollutant source** - Acid rain is the direct result of pollutant emissions into the atmosphere. The two main culprits are sulfur dioxide and nitrogen oxides. In the atmosphere they are chemically transformed into secondary products that acidify rainfall. Because wind may transport these products hundreds or even thousands of kilometers, acid rain can fall far distances from the original pollution source.

   Sulfur dioxide is generally a by-product of industrial processes and burning of fossil fuels. Ore smelting and natural gas processing in Canada and coal-fired power generators in the United States are the main contributors. About half of the nitrogen oxides emitted are by-products of exhausts from cars, trucks, and other forms of transportation. The rest come from coal-fired power generation and other industrial processes.

   There are fewer sources in the western provinces and states, and they are not concentrated, but spread out over a large area. Because pollutant emissions are significantly lower, there is less potential for precipitation to become acidic.

2. **Meteorological Conditions** - Prevailing weather patterns determine where pollutants will be deposited once they leave the source. In North America, the prevailing atmospheric movement is from west to east. Thus, in general, emissions released in the west are transported eastward. Emissions produced in eastern North America also move eastward; they do not affect Western Canada.

When a high-pressure system sits over eastern North America, moist air circulates from south to north and back again. Because the air flows over areas with high pollutant emissions, the concentration of pollutants keeps increasing. When rain falls, it will be acidic. A high-pressure system also occurs in western North America but does not create an air pollution problem because pollutant emissions are so much lower. As well, because there is less rainfall over the prairies, fewer pollutants are washed out of the atmosphere by rain.

While atmospheric movement from west to east benefits Western Canadians by sweeping pollutants away, it also imposes a responsibility to ensure clean air for all neighbours to the east, in the same way that users of prairie rivers must preserve water quality for downstream users.

3. **Environmental Sensitivity** - In some cases nature is able to cope with acid rain. Alkaline lakes and soils - those in areas of limestone - are able to neutralize acidity in precipitation. Many areas in eastern British Columbia and on the prairies have alkaline lakes and soils. Therefore, even if the acidity of precipitation increases, environmental effects should be minimal.

   However, not all areas are naturally protected. Lakes and soils resting on granite bedrock, such as in the Canadian Shield areas of northeastern Alberta, northern Saskatchewan and Manitoba, and in some areas of western British Columbia, cannot neutralize acid precipitation. Lakes in these areas are as vulnerable to acid rain as those in northern Ontario. They must be protected from exposure to acid rain; if not, environmental damage could be swift and serious.

What is Being Done?

The pace of industrialization in Western Canada and the northwestern United States is accelerating. Emissions of sulfur dioxide in Alberta, for example, are projected to double over the next 25 years.

Environment Canada and the environment departments of Alberta and Saskatchewan began a joint study in 1980 to assess the long-term environmental effects of industrial development in northern Alberta and Saskatchewan.

Air quality and the acidity of precipitation and lakes will be monitored to detect whether changes are taking place. Laboratory studies will determine how acid rain affects western soils. Computer programs will be used to simulate the atmospheric movement of pollutants at both the current and projected emission levels so that concentration and deposition of pollutants may be predicted.

(The above was an exerpt from Environmental Canada: ''Acid Rain. The forecast for Western Canada.'')

The following is a brief summary of air pollutants.

Pollutant	Sources	Typical Effects
CARBON DIOXIDE (CO_2)	Low concentration normal in atmosphere, elevated levels due to incrased burning of fossil fuels	Possible increase in global temperature, perhaps resulting in major weather alterations
CARBON MONOXIDE (CO)	Natural decay (93% of total) Internal combustion engines, 25-120 ppm in city traffic Cigarette smoking, 300 ppm in smoke	O_2 deprivation by inactivation of hemoglobin
NITROGEN OXIDES nitric oxide (NO) nitrogen dioxide (NO_2)	Natural processes (1 billion tonnes/yr. world) Internal combustion engines, industrial boilers (50 billion tonnes/yr. world)	Respiratory tract disease, emphysema Damage to vegetation Metal corrosion
SULFUR OXIDES (SO_x) sulfur dioxide (SO_2) sulfure trioxide (SO_3) sulfuric acid (H_2SO_4)	Sulfur containing fuel (coal, oil). SO_2 converts to SO_3 and sulfuric acid in air.	Respiratory tract irritation Damage to vegetation. Destruction of metals, paints, plastics
PHOTOCHEMICAL OXIDANTS ozone(O_3) peroxyacetyl nitrate (PAN) $CH_3CO_3NO_2$	Reaction of NO_2 with vaporized hydrocarbons in sunlight	Reacts with hydrocarbons to form toxic compounds producing eye and respiratory tract irritation, damage to vegetation, deterioration of fabrics, rubber
HYDROCARBONS methane (CH_3) benzene (C_6H_6) (many others)	Partially burned petroleum fuels Car and truck refueling Industrial processes Forest fires and agricultural burning Natural decay	Contribute to formation of photochemical smog, some are carcinogenic
PARTICULATES (aggregates of solids or liquids up to 500 μ diameter)		
asbestos	Building and ship insulation Automobile brake lining wear Certain types of rock used in road surfacing	Asbestosis (emphysema-like effects) Lung cancer, diseases of the lining of the lung cavity
coal dust	Coal mining	Black lung disease of miners
metals		
lead	Fuel anti-knock compounds (use decreasing), coal burning	Disorders of nervous system
mercury	Industrial processes, agricultural chemicals	Disorders of nervous system
allergins	Primarily pollen, especially ragweed Fungi from moldy hay Chemicals used in polyurethane paint	Hay fever, asthma Farmer's lung Asthma
MISCELLANEOUS		
fluorine compounds	Phosphate fertilizer manufacture Aerosol propellants (chlorofluorocarbons such as $CFCl_3$)	Damage to vegetation Possible reduction of ozone layer
industrial and agricultural chemicals		
ammonia	Fertilizer	Corrosive and deadly in high concentrations
chlorine	Industrial processes	Corrosive and deadly in high concentrations, skin disorders in chronic exposure

Figure 2: Sources and Effects of Air Pollutants

Water Pollution

Water is absolutely essential to life for without it no living organism could survive. Water appears to be readily available and perhaps supplies of fresh, potable water are taken for granted. Consider the facts about water quantities by examining the following chart.

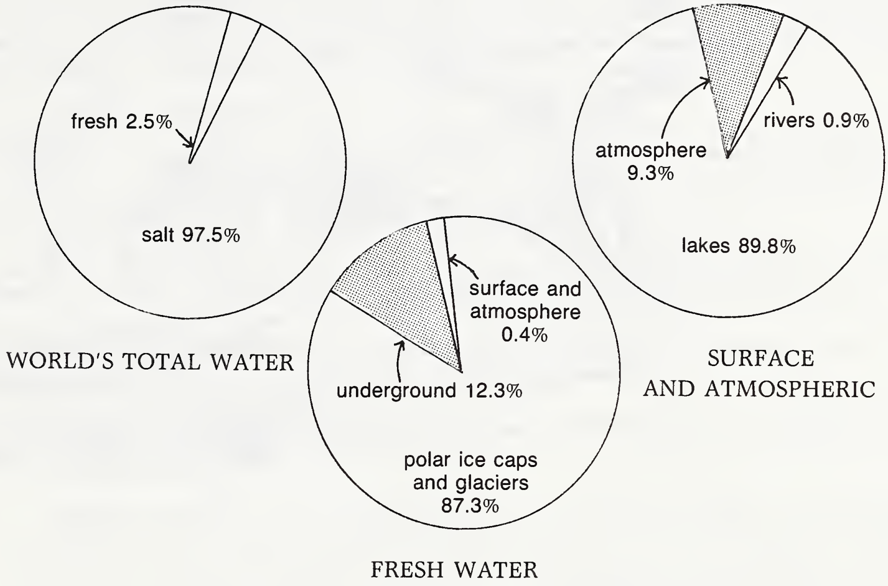

Figure 3: Available Water

One hundredth of one percent of the world's water sustains the earth's total population. Most of the water used is available in the rivers and streams of the world.

Atmospheric water falls as rain or snow. It moves over the land through rivers and lakes, percolates under the surface of the earth and eventually returns to the ocean. At every point along the way and from the ocean as well, water is constantly evaporating and returning to the atmosphere. This cycle is called the **hydrologic cycle**, and acts as a distilling and circulating agent. The distillation serves to purify water of its contaminants. Refer to the diagram on the following page.

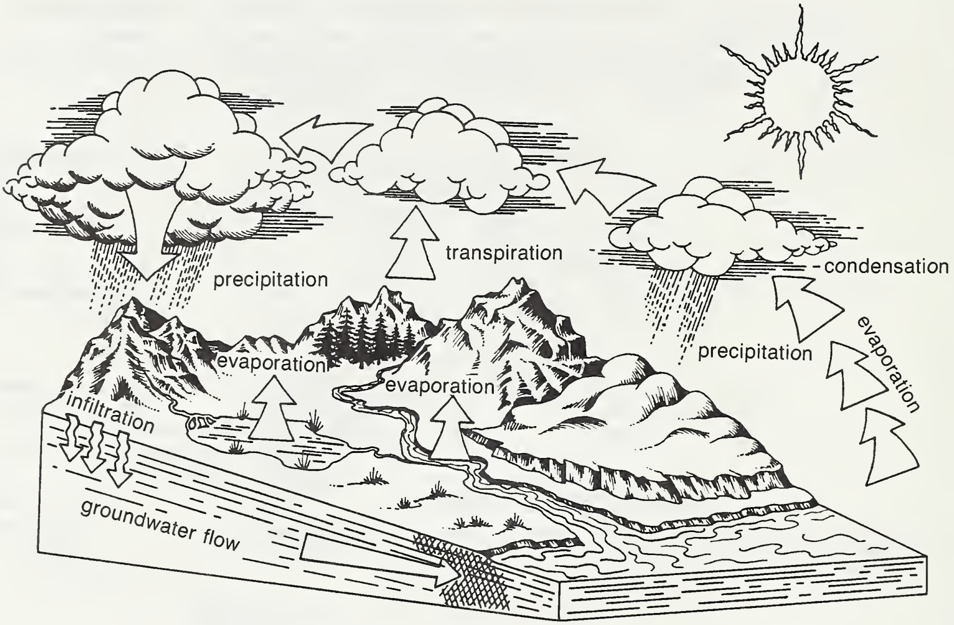

Figure 4: The Hydrologic Cycle

It is evident that what appears to be a great abundance of water for human use is really not great at all. Therefore, if pollution of the small amount continues, the supply will decrease even further.

Water has been described as nature's most versatile compound since it has a number of unique characteristics.

1. Water can absorb heat without a great rise in temperature. As a result, oceans and large lakes effectively reduce extremes of climate by acting as temperature moderators.

2. Water evaporates very slowly compared to most other liquids, but the evaporation that does take place has a significant cooling effect. This allows for maximum cooling in industrial processes with a minimum of water.

3. Water will adhere to certain material, but only if oxygen is present in the chemical structure of the other material.

   Adhesion, the attraction to other substances, and cohesion, water's attraction to itself, combine to produce capillary action, the ability of water to rise. This characteristic allows plants to draw water from the soil, and allows the soil to hold water against the pull of gravity. Without capillary action, plant growth would be impossible.

4. Probably the most important characteristic of water is its ability to dissolve other substances. Most known chemical elements can be found in solution in the earth's waters. Because of its solvent characteristic, water is essential to life. It is the agent which transfers within living animals and plants the compounds without which life is not possible.

Strangely enough, the properties that make water such a versatile compound also aid in making it so susceptible to pollution. There are a large number of possible water pollutants. In fact, any element not occuring naturally in water can be considered a pollutant. Following are some of the more troublesome pollutants introduced into rivers and lakes by human activity:

Nutrients: These are common elements such as oxygen, carbon, nitrogen and phosphorus required to support life. Excessive nutrients often cause troublesome algae growth leading to eutrophication. Excessive nutrient build up causes an increase in plant life and a deficiency of oxygen in the water. Death of organisms may occur.

Phenols: These are organic chemicals which may, in high concentrations, be toxic to fish. They may also cause unpleasant tastes and odors when water is chlorinated.

Oil and Grease: These may be liquid fats of animal or vegetable origin, or oily or waxy mineral oils, often originating with the petroleum industry.

Heavy Metals: These are metals such as zinc, nickel, copper and mercury which may be highly toxic to life in the river.

Thermal Pollution: Many industries use water but do not consume it, and so return it to the river after use. The returned water is often polluted though, either by the addition of undesirable material or by heating during use as in cooling processes. Pollution such as this is a major problem where many industries are concentrated along one stretch of a river, as in the case in both Edmonton and Calgary.

Pesticides and herbicides: Farmers everywhere depend upon rainfall to make their crops grow but careless farming methods can cause pollution. A fast runoff of rainfall results in erosion of precious topsoil and can cause streams to become filled with sediment. As well, it may wash agricultural chemicals such as fertilizers and pesticides into streams causing damage to stream life and negating their usefulness on the land. Some of these chemicals are toxic; their use is carefully controlled. Please refer to the chart illustrating the ''Ripple Effect of Persistant Use of Pesticides.'' on page 21.

Bacteria: Undesirable bacteria may enter a river through insufficiently treated sewage. Rivers are and can be used effectively to dispose of wastes, but abuse can easily lead to a severe pollution problem. A watercourse is able to absorb certain amounts of wastes. Sewage going into a river is diluted, and bacteria act on it to break it down. With the high demand placed on rivers as carriers of waste, it is necessary that this process of treatment be maintained and monitored constantly.

Suspended Solids: These are undissolved, often minute particles of matter suspended in water giving it a turbid appearance. Included in this category is soil and dust which may be washed into a river.

In considering stream pollution, the amount of water in a river and consequently the amount of dilution that takes place is of prime importance. Partially for this reason, pollution always shows up more during the winter when the lack of rainfall and runoff causes low flows in rivers.

Although human beings are the major source, many of these pollutants do occur in nature. Erosion carries soils and heavy metals into watercourses. High concentrations of mercury have been noted where no human activity has taken place. Phenols in water may be the result of decaying vegetable or animal matter, and muskeg areas may add an odor to the water.

These natural pollutants will always exist. Lakes and rivers can handle this load, as well as some additional pollutants introduced by people. The task that faces us is one of controlling the types and amounts of material going into the watercourse, in order to maintain the water in a useful condition for ourselves and for generations to come.

The following is a summary of pollutants of freshwater.

Pollutant	Typical Effects	Sources
DISEASE AGENTS bacteria cholera typhoid fever bacterial dysentery		
viruses	Various acute or chronic diseases	Raw human sewage contaminating food and drinking water. Reduced substantially in developed countries due to chlorination of water supplies and sewage treatment
infectious hepatitis	Dysentery (severe diarrhea)	
poliovirus protozoa		
Entamoeba histolytica	Dysentery	
Naegleria	Amebic meningoencephalitis	Thermally polluted water
PETROLEUM	Directly toxic to all forms of life, physical smothering effects	Waste from transportation, heating, industrial accidents. Major source is unwanted motor and industrial oils (3 million tonnes/yr. worldwide)
OXYGEN USING WASTES (biodegradable)	Reduction of available oxygen causes loss of desirable organisms and replacement by anaerobes, with resultant production of odorous toxic substances	Sewage Paper mill wastes Meat-processing wastes Feed-lot runoff
SYNTHETIC ORGANIC COMPOUNDS detergents		
biodegradable	Phosphate build-up	Household, commercial washing
non-biodegradable	Long acting surface effects--foaming rivers.	Household, commercial washing
pesticides	See page 20.	Agricultural, industrial wastes
herbicides	See page 20.	Agricultural, industrial wastes
industrial wastes	Thousands of substances involved in an industrialized economy produce a wide gamut of effects.	Industrial accidents, waste disposal
INORGANIC SUBSTANCES		
arsenic	Skin and liver cancer, a cumulative lethal substance	Arsenic-based pesticides and herbicides account for most of 13,000 tonnes/yr worldwide production
cadmium	Circulatory and kidney disease	Mine wastes, battery manufacturing, electroplating
chlorine	Generally deadly to aquatic life; possible carcinogenic effects as it reacts with organic substances in water	Industrial, water and sewage purification
mercury	Central nervous system and kidney disorders	Industrial wastes, agriculture (fungicides), coal burning
sulfuric acid	Directly lethal to aquatic life	Coal mine wastes
PLANT NUTRIENTS		
nitrates, nitrites	If present in drinking water are dangerous to infants by inactivating hemoglobin. May form carcinogenic N-nitrosoamines	Fertilizer runoff, manure, natural weathering, nitrogen fixation by microorganisms
phosphates	Phosphate build-up	Agriculture
potassium compounds	Build-up of potassium compounds	Agriculture

Figure 5: Freshwater Pollutants

Exercise 1

Part One: Air Pollution

1. The IQUA index is based on readings of what 5 major pollutors.

   (a) ______________________________

   (b) ______________________________

   (c) ______________________________

   (d) ______________________________

   (e) ______________________________

2. Explain why CO from incomplete combustion poses a health danger.

   ____

   ____

   ____

   ____

   ____

3. What are three results of high ozone concentrations?

   (a) ______________________________

   (b) ______________________________

   (c) ______________________________

4. Basically, pollution can be defined as ______________________ .

5. Industrial pollutants and particles in the atmosphere can make rainfall more acidic than normal resulting in the condition referred to as __________ __________.

6. The three elements needed for acid rain to develop and pose a serious problem are:

   (a) ______________________________

   (b) ______________________________

   (c) ______________________________

7. List some of the effects of exposure to the following air pollutants:

   carbon monoxide - ______________________________

   ____

nitrogen dioxide - ______________________________

____

ozone - ______________________________

____

coal dust - ______________________________

____

asbestos - ______________________________

____

ammonia - ______________________________

____

chlorine - ______________________________

____

Part Two: Water Pollution

1. List 4 characteristics that illustrate water to be a versatile compound.

(a) ______________________________

____

(b) ______________________________

____

(c) ______________________________

____

(d) ______________________________

____

2. List 5 pollutants of freshwaster and the effects they create.

(a) ____________________

____

(b) ____________________

____

(c) ____________________

____

(d) ____________________

____

(e) ____________________

____

Please check your answers with those given on page 26.

Soil Pollution

Soil pollution is a serious problem and has reached a high level of public awareness as human technology continues to advance. A soil pollutant may be considered as being any substance, chemical or otherwise, which interferes with the soil's ability to yield high quality crops, which creates a hazard to the health of living organisms and which creates litter. Soil pollution, air pollution and water pollution are often related in that the pollutant may be transferred from one to another.

For the purposes of this lesson, three categories of materials which constitute soil pollutants will be considered. These three are **solid wastes, chemical wastes,** and **radioactive and hazardous wastes.**

1. Solid Waste

The control of solid waste disposal is an important part in the program of prevention of soil pollution. Tin cans, empty packages, food scraps, beverage bottles and wrappers are but a very few examples of refuse created by members of a community each day. Commercial wastes from retail and wholesale businesses, old car bodies, old household appliances and furniture, industrial wastes, feed lot manure, leaves, grass cuttings and garden debris, as well as many other forms of materials add to the very long list of waste that must be disposed.

Refuse disposal problems are not new to the modern world. At almost every step in the development of civilization, the amount of solid waste refuse has increased. Members of primitive societies handled the problem easily. They simply moved to a new location and left the rubbish behind. Modern fixed communities of today's world are not so fortunate. As these communities increase in size, less and less land is available for refuse disposal.

Many methods of solid waste disposal have been attempted, some have been discarded while others are still being practiced. New methods are evolving.

The **open dump** or **nuisance ground** is still used primarily in rural areas. These are unsightly collections of all garbage and refuse of a community. Frequently, attempts are made to burn some of this material. Smoke, foul odors and bits of paper carried by the wind create very unsightly and unpleasant conditions in the surrounding area. These open dumps are an ineffective means of disposing garbage safely since there are few or no regulations or controls on the materials being disposed. Industrial wastes could be deposited here.

Incinerators at one time were used but these were only partially successful as high temperature incinerators that are clean burning are expensive. From an economic point of view, open low budget pits supersede the use of efficient incinerators that must be maintained and staffed.

In Alberta, the greatest quantities of solid refuse are disposed of in **landfills**. A landfill is an area where a layer of refuse is deposited in a prepared trench or excavation. It is then compacted by some means to layer depth of approximately 0.6 m. After the compacting the layer of refuse is covered by a layer of soil. The next layers of refuse and soil are added alternately until the excavation is filled. The final covering layer of soil must be at least 0.6 m deep. A landfill built on a clay base, planned and operated properly is relatively safe. This method of disposal limits immediate danger to health, is relatively free of odors and the cost is comparatively low. A landfill is not the best way to dispose of wastes but it is the most economical in the short term. In some cases, it has been proven that a landfill is not always ''safe''. Once the landfill is covered or capped, aerobic organisms no longer break down the wastes; instead anaerobic organisms function. Methane gas is produced as a product of this action. This gas must be released in a safe manner. If released properly, methane gas can be collected and used as an energy fuel. Therefore, the landfill once covered is still an ''active organism'' breaking down the wastes deposited in the earth by people.

Once the landfill is completed it remains in the area forever. It can be unsightly at times if it does not fit into the geographic layout of the environment. Also, if industrial wastes are inadvertently deposited they could cause ''landfill leaks'' and lead to health problems. However, in Alberta precautions are taken and the landfills in urban areas are carefully monitored to ensure wastes are disposed of properly.

The advantage of a properly developed landfill is that normally unusable land may be made useful for purposes such as parks. The safety of an old landfill site is dependent on its location, construction, and wastes deposited in it.

The ultimate form of disposal is the high efficient, clean-burning but expensive **incinerator**. Wastes would be broken down and others would be recycled. Resource recovery would operate ''hand in hand'' with incinerators. Recycling useable forms of refuse is becoming more popular. Industries are making new products from what was once waste material. Glass is being recycled in the form of glasphalt, concrete, building bricks and reflective paint. Car bodies are being recycled and the steel is used in the production of reinforcing steel for concrete structures. Paper is another product being recycled and used in the manufacture of several secondary products such as building materials.

Unfortunately, when disposing of solid wastes, short-term costs seem to be favored over long-term benefits. It is for this reason landfills are the dominant form of solid waste disposal.

2. Chemical Waste

From the time of World War II to the present, a very great number and variety of chemical compounds have been developed. Eventually, these compounds contact the soil by some means or other for purposes of rodent, insect, weed and fungus control. These are generally referred to as rodenticides, insecticides, herbicides and fungicides. All fall under the general term **pesticides**. We may add fertilizers to this list, although application of these chemicals is for a different purpose.

Fertilizers are chemicals designed to supply growing plants with elements necessary for complete growth when such elements are lacking in the soil's natural makeup. When used with proper consideration for the amounts and types to be applied after soils have been analyzed, fertilizers do play a positive role in food production. However, overuse of fertilizers often results in surplus nitrates being washed into bodies of water where they create problems. Water supplies, heavily contaminated with nitrates, produce harmful effects on organisms. Fertilizers are widely used in homes, gardens and agricultural areas of the world.

Rodenticides, insecticides, herbicides and fungicides are beneficial if used with extreme care and caution. However, widespread overuse of these chemicals has created and will continue to create serious problems. Such agents are used quite freely in the home, on lawns, in gardens, in city parks as well as in large agriculture fields and forests in rural areas. Eventually, many of these pesticides end up in bodies of water where they affect aquatic organisms.

These poisons have the ability to be passed along a food chain from producer to consumer. Consequently, it is the animals at the upper end of the food chain that have a high concentration of chemicals in their bodies. These chemicals bring about effects far removed from their original intent. (See the pesticide chart on page 20.)

Mineral pollution of the soil is important for often plants absorb minerals that are harmful to organisms. This type of soil pollution is becoming an increasingly serious problem in spite of the fact that it is not as obvious as water or air pollution. The following are examples of mineral sources which lead to soil pollution:

Source	Mineral
Smelter slag Phosphate fertilizers	Lead, cadmium
Pesticides	Arsenic, mercury, lead
Coal and wood ash Automobile exhaust - lead eventually settles to ground	Lead

Various industrial operations, particularly large smelters, are capable of adding large amounts of these industrial pollutants.

Because of the widespread use of chemicals resistant to breakdown, continued application causes a buildup of harmful agents to the point where their abundance exceeds nature's ability to remove them. Therefore, they become pollutants and the soil becomes polluted.

The following chart illustrates some effects of widely used pesticides.

Chemical	Effects	Sources
PESTICIDES Chlorinated Hydrocarbon Insecticides DDT	Kidney and liver damage, endocrine disorders, impaired neural function	Since 1945 used worldwide as insecticide Use has declined but still highly persistent in environment Other chlorinated insecticides include aldrin dieldrin chlordane heptachlor endrin, methoxychlor
Kepone (chlordecone)	Serious neurological effects, possible liver cancer	Insecticide manufacture (accidental contamination)
Organophosphate Insecticides Malathion	Acute effects on nervous system	General purpose insecticide the least toxic of the organophosphates Not persistent in environment
Herbicides 2,4,5-T	Chloracne (persistent skin disorder), liver and kidney failure, developmental abnormalities	Used as weed and vegetation killers

Figure 6: Effects of Pesticide Use

"Ripple Effect of the Persistant Use of Pesticides"

The diagram on page 21 is to be used in conjunction with the material on pollution.

This diagram illustrates the events that occur through the persistant use of pesticides. The center is the actual event of spraying the crop with pesticides. The ripple surrounding it is the initial result of that action. Each subsequent ripple indicates the buildup of events occurring from the use of pesticides. To best use the chart follow one event all through the ripple buildup, for example:

initial event → "grain eating vertebrates may be poisoned" → "bird migration spreads pesticides" → "predatory birds and mammals accumulate pesticides" → . . .and so on.

Study the diagram carefully and think how it relates to the environment and our actions to control the environment.

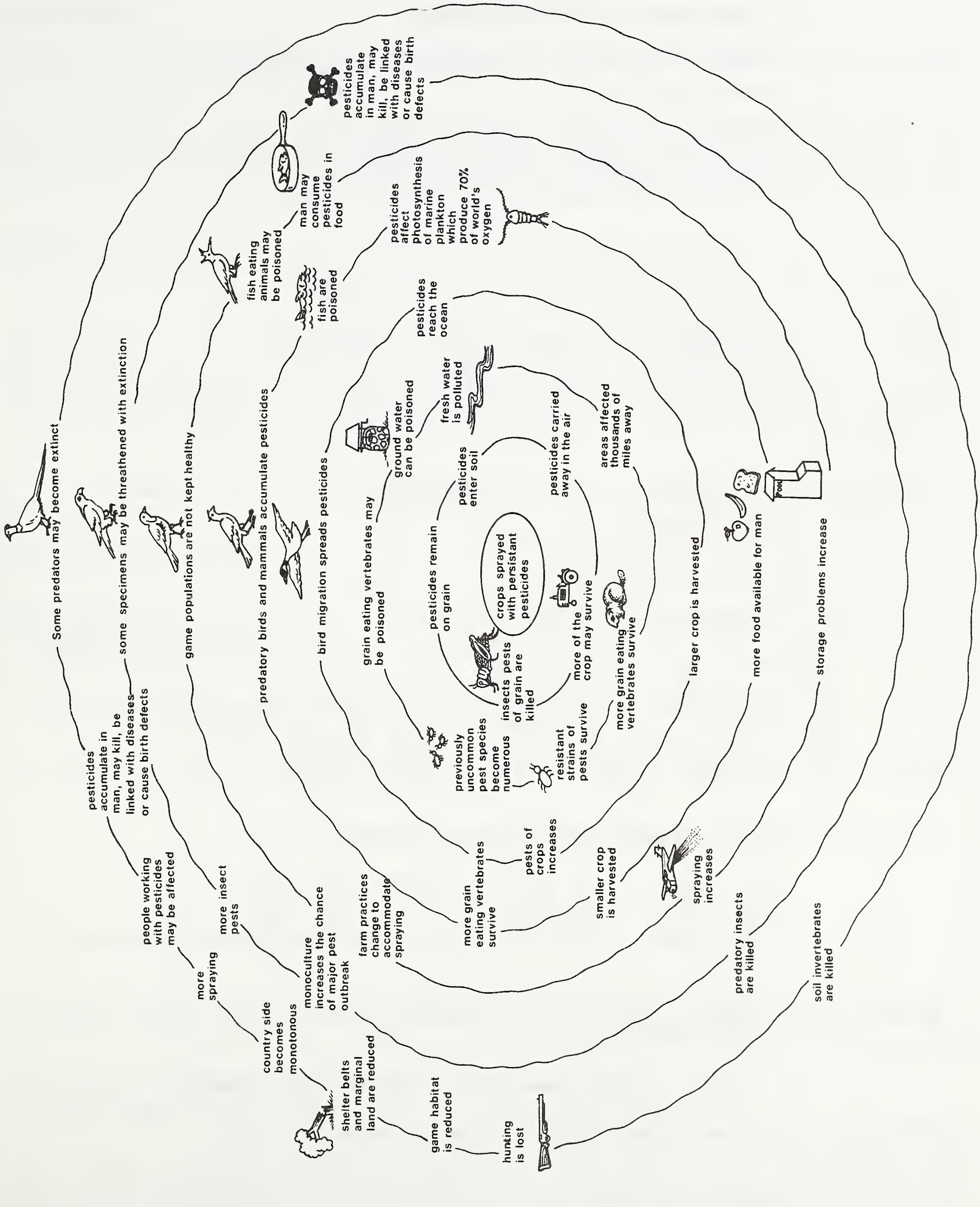
crops sprayed with persistant pesticides
pesticides remain on grain
pesticides enter soil
pesticides carried away in the air
more of the crop may survive
insects pests of grain are killed
grain eating vertebrates may be poisoned
ground water can be poisoned
fresh water is polluted
areas affected thousands of miles away
more grain eating vertebrates survive
resistant strains of pests survive
previously uncommon pest species become numerous
bird migration spreads pesticides
pesticides reach the ocean
larger crop is harvested
pests of crops increases
more grain eating vertebrates survive
predatory birds and mammals accumulate pesticides
fish are poisoned
pesticides affect photosynthesis of marine plankton which produce 70% of world's oxygen
more food available for man
FOOD
smaller crop is harvested
farm practices change to accommodate spraying
game populations are not kept healthy
fish eating animals may be poisoned
man may consume pesticides in food
storage problems increase
spraying increases
monoculture increases the chance of major pest outbreak
more insect pests
some specimens may be threathened with extinction
pesticides accumulate in man, may kill, be linked with diseases or cause birth defects
predatory insects are killed
shelter belts and marginal land are reduced
country side becomes monotonous
more spraying
people working with pesticides may be affected
Some predators may become extinct
pesticides accumulate in man, may kill, be linked with diseases or cause birth defects
soil invertebrates are killed
game habitat is reduced
hunting is lost

Figure 7: Ripple Effect of Persistant Use of Pesticides

3. Radioactive and Hazardous Wastes

At present, radioactive wastes are not in great abundance in Alberta. Those present are removed in two ways:

(a) Radioactive wastes are held in lead containers or steel insulated containers until decay is such that radiation is no longer dangerous. Materials are then deposited in the conventional manner of a landfill or are incinerated.

(b) Radioactive wastes with low level radioactivity but persistant in nature are shipped in properly sealed insulated containers to Chalk River in Ontario. In Ontario, wastes are reprocessed and stored in containers underground indefinitely.

Hazardous wastes are generally defined as "any material that would do harm if released to the environment." This term can include a wide variety of wastes but generally hazardous wastes do not break down and many are known to be carcinogens. Examples of two such wastes are PCB and PVC. Refer to the following diagram that illustrates their use and effects.

Chemical	Typical Effects	Sources
INDUSTRIAL CHEMICALS PVC (polyvinyl chloride)	Liver cancer	About 10 million tonnes yr worldwide production. a basic component in plastics industry
PCB (polychlorinated biphenyl)	Long-term effects similar to DDT	Used for heat transfer and insulation in power transformers lubricants Highly persistent in environment. accumulated by body fat
PBB (polybrominated biphenyl)	Persistent skin disorders, joint disease. neurological disorders	From plants manufacturing fire retardants

Figure 8: Hazardous Wastes and Their Effects.

In Alberta, hazardous wastes are deposited by three methods.

(a) Small volumes of chemicals used by laboratories and schools are neutralized at the source.

(b) The University of Alberta has a disposal facility to handle its own wastes and can handle some outside sources.

(c) Larger volumes of wastes are handled by a company in Alberta that ships hazardous wastes to Oregon where they are placed in a landfill. Proper procedures are taken to neutralize the wastes and monitor the storage.

At present, Alberta has located a site in Swan Hills to build a reprocessing plant for hazardous wastes. These wastes will be reprocessed into less hazardous forms and be deposited in a well monitored landfill.

Noise Pollution

The following written material is an excerpt taken from "A Pollution Primer" prepared by Environment Canada.

Noise, like other pollutants, makes our environment less hospitable. Once we become accustomed to the presence of loud noise we tend to take less notice of it and as a result can subject ourselves to dangerous levels without really being aware of it. Real harm can be done. Excessive noise contributes to human stress, often producing such effects as hypertension, fatigue and impaired hearing.

The intensity of sound is measured in decibels on a basic scale ranging from 0 to 150. Zero represents the faintest sound that the unaided human ear can detect. A purring cat registers approximately 25 decibels while a barking dog registers about 65 decibels. Continuous noise above 80 decibels can cause hearing loss and a sound level of 90 decibels can be tolerated only for short periods. Temporary deafness can be caused by even short exposure to levels of 100 to 105 decibels. A sound of 130 decibels is perceived not only as sound but also as a painful sensation in the ear. Typicals sounds of high intensity are those created by a subway train screeching around a curved track (95 decibels), motorcycles (110 decibels), a jet plane taking off (150 decibels).

Refer to the following diagram illustrating the decibel values of environmental sounds.

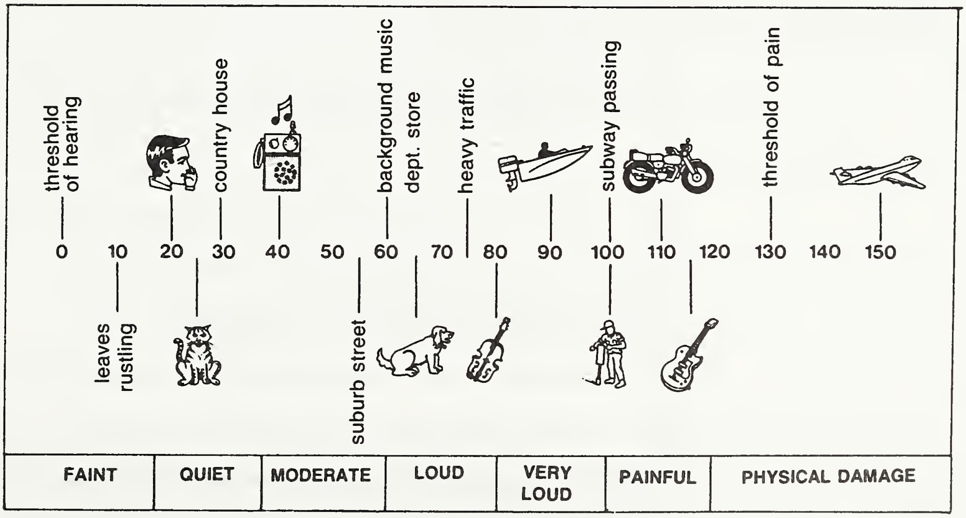

Figure 9: Decibel Values of Environment Sounds

Most cases of actual hearing loss are due to industrial noise and occur as the result of continuous exposure to high levels over a period of years. Home and recreational noises, however, can be a major irritant. Power mowers, radios, stereos, outboard motors, chain saws and powered appliances make it almost impossible to escape unwanted noise anywhere near a settled area.

Aside from hearing loss, noise can increase body tensions, affecting blood pressure and the functions of the heart and nervous system. It can also cause skin to pale, muscles to tense, blood vessels to constrict, and trigger such ailments as stomach ulcers and allergies.

Our present day urban environment is steadily becoming more noisy, some say at an average of one decibel per year. Attempts are being made, however, to remedy the situation. An example is the placement of berms or sound barries between major roadways and residential areas.

Conclusion

In conclusion then, there is no doubt that pollution is a serious and complicated problem with no quick and easy cure. Pollution is the individual's problem as well as the problem of both industry and government. Pollution and its treatment is also an economic problem.

How much do you as an individual contribute to the problem of pollution? Are you part of the problem or the solution?

Exercise 2

1. What is a soil pollutant?

2. Three methods of solid waste disposal are:

   (a)

   (b)

   (c)

3. List two chemicals considered to be hazardous.

   (a)

   (b)

   How would large quantities of the above chemicals be disposed of?

4. List the ill effects of pollution due to the misuse of the following chemicals:

(a) DDT: ____________________

____

____

(b) Malathion: ____________________

____

____

(c) 2,4,5-T: ____________________

____

____

5. At what decibel level is sound or noise pollution painful?

____

6. Why is it difficult to identify noise pollution?

____

____

____

____

____

Please check your answers with those given on page 27.

ANSWERS TO KEYED EXERCISES

Exercise 1, pp. 15 - 17.

Part One: Air Pollution

1. (a) **carbon monoxide (CO)**
   (b) **ozone (O_3)**
   (c) **particulates**
   (d) **sulfur dioxide (SO_2)**
   (e) **nitrogen oxide (NO)**

2. **CO replaces O_2 in red blood cells, reducing the amount of O_2 that reaches body cells. Lack of oxygen affects the brain. Symptoms include: impaired perception and thinking. CO also worsens conditions of respiratory disease and sufferers of chronic heart disease.**

3. (a) **eye irritation**
   (b) **breathing difficulty**
   (c) **vegetation damage or decreased visibility**

4. **contamination**

5. **acid rain**

6. (a) **pollutant sources - eg. industries**
   (b) **meteorological conditions - winds that direct pollution**

   (c) **an environment sensitive to acid rain - one which cannot neutralize these effects**

7. carbon monoxide - **inactivation of hemoglobin for O_2 transport**

   nitrogen dioxide - **metal corrosion**

   ozone - **forms toxic compounds resulting in eye and respiratory tract irritation, damage to vegetation, deterioration of fabric, and rubber**

   coal dust - **black lung disease of miners**

   asbestos - **emphysema-like condition**

   ammonia - **corrosive, lethal in high concentrations**

   chlorine - **corrosive, lethal in high concentrations, skin disorders in chronic exposure**

Part Two: Water Pollution

1. (a) acts as a temperature moderator

   (b) evaporates slowly but in doing so acts as a cooling agent

   (c) will adhere to other materials allowing for its transport in plants

   (d) it is a solvent in which other substances can be dissolved

2. Refer to Figure 5: Freshwater pollutants p. 14.

Exercise 2, pp. 24 - 25

1. A soil pollutant is a substance that interferes with the soil's ability to yield high quality crops or creates a hazard in the environment.

2. (a) use of open pit or nuisance ground
   (b) landfills
   (c) incinerators and recycling

3. (a) PCB Large volumes of wastes are shipped to a landfill
   (b) PVC in Oregon

4. (a) DDT: kidney and liver damage, endocrine disorders, impaired neural function

   (b) Malathion: affects nerve transmission in nervous system

   (c) 2,4,5-T: skin disorder, liver and kidney failure, developmental abnormalities

5. 100 - 150 decibels

6. Everyone's tolerance for noise levels differs slightly and according to individual tastes one person's noise may be another's "music".

EXERCISES TO BE SENT IN FOR CORRECTION

Part One: True or False Questions

Indicate whether the following statements are TRUE or FALSE by circling the correct letter at the beginning of each statement.

T F 1. Pollution is not a major concern to the average person until he or she is affected by it personally.

T F 2. An individual cannot do anything to lessen the impact of pollution on the environment.

T F 3. As population and technology increase so does the kind and amount of pollution.

T F 4. Air pollution is solely a result of human activities.

T F 5. Normally, rainfall is slightly acidic.

T F 6. An increase in air pollution results in an increase in cardiovascular disease.

T F 7. A landfill once properly capped is a safe environment.

T F 8. Once capped, a landfill is no longer "active" in breaking down wastes.

T F 9. Radioactive wastes, at present, do not pose a great disposal problem in Alberta.

T F 10. Noise is not a real pollution concern.

T F 11. The solutions to the problems of pollution are related to the economics of a region.

T F 12. Alberta is an acid rain free environment.

Part Two: Fill-in-the-blanks

Complete each of the following statements by filling in the numbered blank on the right.

(a) The three locations for air quality measurement are located in ___(1)___, ___(2)___, and ___(3)___ areas.

(b) A colorless, odorless and tasteless gas produced by incomplete combustion of fuel is ___(4)___.

(c) ___(5)___ is the result of photochemical action on hydrocarbons and nitrogen oxides.

(1) ____________________

(2) ____________________

(3) ____________________

(4) ____________________

(5) ____________________

(d) ___(6)___ is capable of forming acid rain and contributes to the creation of photochemical smog.

(e) A by-product of burning fuels containing sulfur is ___(7)___ .

(f) In Edmonton, the majority of total emissions comes from ___(8)___ whereas in Calgary 83% of emissions is from ___(9)___ .

(g) A twenty-five year prediction estimates an ___(10)___ in acid rain development in Alberta due to an increase in emissions of ___(11)___ .

(h) The percentage of freshwater to salt water is ___(12)___ to ___(13)___ .

(i) The condition whereby excessive nutrients cause an increase in plant life and deficiency of O_2 in water is ___(14)___ .

(j) Water used by industries and returned to the river in a polluted form contributes to ___(15)___ .

(k) The method of most efficient solid waste disposal but most expensive is ___(16)___ .

(l) The majority of Alberta wastes are deposited in ___(17)___ .

(m) ___(18)___ is a by-product of anaerobic organisms breaking down solid matter.

(n) ___(19)___ have the ability to be passed along a food chain from producer to consumer.

(o) Any material that would do harm if released to the environment is considered a ___(20)___ waste.

(6) ______________________

(7) ______________________

(8) ______________________

(9) ______________________

(10) ______________________

(11) ______________________

____

(12) ______________________

(13) ______________________

(14) ______________________

(15) ______________________

____

(16) ______________________

(17) ______________________

(18) ______________________

(19) ______________________

(20) ______________________

Part Three: Short Answer Questions

1. Give 3 reasons why Eastern Canada is more susceptible to acid rain than is Western Canada.

2. List an example of how the four kinds of pollution affect you in your daily life.

   (a) Air -

   (b) Water -

   (c) Land -

   (d) Noise -

3. At times atmospheric conditions are such that contaminants in the air cannot escape from an area such as a valley or city and therefore they stay close to the ground and become harmful to life in that area. The condition created is a temperature inversion. Explain how a temperature inversion develops.

4. Assume you live in a community of 10 000 population and that the average amount of solid refuse per person is created in this community. Also assume you have been asked for advice about solid refuse disposal; how it may be disposed of effectively, realistically, efficiently and eonomically. You have also been asked for advice on putting the area to practical use after the addition of refuse to that area is no longer practical. What would you suggest?

____

____

____

____

____

____

5. Referring to the diagram illustrating the Ripple Effect of Persistent Use of Pesticides cite an example of pesticide use in our society that shows the "ripple" effect for one particular aspect of pesticide use. Consult recent newspapers for an article that could support your answer.

____

____

____

____

____

6. Mention 5 ways you contribute to pollution and 5 ways you help combat pollution.

CONTRIBUTE	COMBAT
(a) ____________	(a) ____________
(b) ____________	(b) ____________
(c) ____________	(c) ____________
(d) ____________	(d) ____________
(e) ____________	(e) ____________

Please submit pages 28 to 31 for correction.

END OF LESSON 20

DIPLOMA EXAMINATION

CURRICULUM SPECIFICATIONS
for
BIOLOGY 30

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Alberta
EDUCATION
April 1986

BIOLOGY 30 CURRICULUM SPECIFICATIONS

A. Program Elements

The Biology program is based on four elements: process skills, psychomotor skills, attitudes, and concepts (subject matter). The percentage emphasis of each component for instruction in Biology 30 is listed in the table below. Even though each component is listed separately, instruction should integrate process skills, psychomotor skills and attitudes with the development of concepts. Not all these elements have equal emphasis at each course level. Hence, development of these components should take place as the concepts are presented.

Content	Emphasis
Process Skills	20%
Psychomotor Skills	5%
Attitudes	15%
Concepts (Subject Matter)	60%

B. Priority Weightings

The following code is used in the specifications to indicate curriculum and instruction priority.

A = high priority
B = medium priority
C = low priority

PROGRAM COMPONENTS

A. PROCESS SKILLS 20%

PRIORITY RATING		EMPHASIS IN PER CENT
A	1. Questioning 1.1 Formulating and expressing relevant questions 1.2 Defining problem statements 1.3 Recognizing limitations to scientific investigation of given questions and problems	20%
A	2. Proposing Ideas 2.1 Formulating hypotheses 2.2 Stating predictions	
A	3. Designing Experiments 3.1 Defining operationally 3.2 Identifying and controlling variables 3.3 Determining procedures 3.4 Evaluating experimental designs and suggesting modifications	
B	4. Gathering Data 4.1 Observing accurately 4.2 Measuring accurately 4.3 Recording data clearly and completely 4.4 Estimating quantities and measures	

PROGRAM COMPONENTS Cont.

PRIORITY RATING		EMPHASIS IN PER CENT
B	5. Processing Data 5.1 Organizing and presenting data 5.2 Determining patterns and trends in data 5.3 Determining experimental error both for original data and for values derived from these data	Cont.
A	6. Interpreting Data 6.1 Identifying limits to interpretations 6.2 Generating appropriate explanations, theories and/or models 6.3 Generating ideas for extending knowledge related to the area of investigation	

B. PSYCHOMOTOR SKILLS 5%

PRIORITY RATING		EMPHASIS IN PER CENT
Equal priority	Develop and calibrate tools and instruments	5%
	Develop and manipulate various tools, instruments, apparatus, and materials proficiently	
	Carry out various accepted procedures and techniques, for example, laboratory work, field work, and preparations	
	Develop and follow safe practices and procedures	

C. ATTITUDES 15%

Equal priority	Awareness - Develop an awareness of the biological factors related to issues of current interest	15%
	Appreciation - Develop an appreciation of the interdependence of human organ systems and their functioning in a homeostatic relationship	

D. CONCEPTS (SUBJECT MATTER) 60%

PRIO-RITY RATING	CONCEPT		EMPHASIS IN PER CENT
B	Cellular processes are fundamental to life	1. Animal cells exhibit complex structure and function. a. Membranes b. Cytoplasm and nucleoplasm c. Organelles	7%
A		2. Substances necessary for life are transported by physical and chemical processes. a. Diffusion and osmosis b. Active transport c. Endocytosis and exocytosis	
A	Homeostatic mechanisms regulate the body and its systems.	1. Negative feedback.	3%
		2. Enzyme action regulates cell metabolism.	
		3. Competitive inhibitors interfere with enzyme activity.	
		4. Acids, bases and buffers.	
A	Humans must take in and process the required nutrients for absorption.	1. Basic organic and inorganic substances provide requirements for cell maintenance and growth. a. Identify the importance of carbohydrates, proteins, lipids, nucleic acids, vitamins, minerals and water. b. Identify the general structural and functional differences between carbohydrates, lipids and proteins.	13%

PROGRAM COMPONENTS Cont.

PRIORITY RATING	CONCEPT		EMPHASIS IN PER CENT
		c. Carbohydrates, lipids and proteins can be identified in the lab. i. Carbohydrates (Benedict's solution and iodine) ii. Lipids (Sudan IV and Translucence) iii. Proteins (Biuret solution)	
B		d. The anatomy of the digestive system consists of the mouth, esophagus, stomach, small intestine, large intestine and anus.	
		e. Accessory structures which assist in the process of digestion are salivary glands, liver, gall bladder and the pancreas.	Cont.
A	Cont.	f. Digestion includes the physical and chemical breakdown of ingested macromolecules, preparing them for absorption. i. Oral (Salivary Amylase) ii. Gastic (Pepsin, HCl) iii. Intestinal (Carbohydrases, Bile, Lipase, Bicarbonate ion)	
		g. The release of digestive enzymes is under: i. Mechanical control (Peristalsis) ii. Hormonal control (Gastrin, Secretin) iii. Nervous control	
B		h. Nutrients are absorbed into the circulatory system.	
		i. The large intestine absorbs water and vitamins, stores, then ejects undigested materials.	

PRIORITY RATING	CONCEPT		EMPHASIS IN PER CENT
	Cont.	j. Malfunctions of the digestive system can result in ulcers or gall stones. k. Foreign substances may be absorbed and retained by body tissue.	
B	Body fluids distribute essential nutrients to and carry wastes away from tissues.	1. The heart and its major blood vessels are structured to facilitate circulation.	11%
		2. Blood circulation occurs in a closed system consisting of arteries, arterioles, capillaries, venules and veins.	
A		3. Homeostatic controls maintain cardiac output and blood pressure. a. Capillary fluid exchange b. The medulla oblongata processes information from: i. Stretch receptors ii. Carbon dioxide c. Heart tissue is self-stimulating.	
A		4. Blood is the primary circulating body tissue fluid. a. Cellular components have specific functions. i. Erythrocytes transport gases. ii. Leukocytes control foreign invading bodies through antibody production and phagocytosis. iii. Platelets initiate blood clotting.	

PROGRAM COMPONENTS Cont.

PRIORITY RATING	CONCEPT		EMPHASIS IN PER CENT
	Cont.	b. Noncellular components include plasma proteins, inorganic molecules, nutrients, and waste molecules. c. Specific proteins determine blood types. i. A, B, O factors ii. Rh factor d. Oxygen concentration regulates red blood cell production.	Cont.
A		5. Malfunctions in the circulatory system may result in heart attacks and strokes.	
B		6. Lymph is a secondary circulating body fluid. a. Lymph system b. Lymph function	
B	Breathing precedes gas exchange and transport.	1. The anatomy of the respiratory system includes the: a. Trachea b. Bronchi c. Bronchioles d. Alveoli	6%
B		2. Mechanics of breathing include inhalation and exhalation.	
B		3. Gas exchange occurs between the environment, blood, and body tissues.	

PRIORITY RATING	CONCEPT		EMPHASIS IN PER CENT
A	Cont.	4. Hemoglobin and blood plasma are necessary for gas transport. a. Oxygen is transported as part of the oxy-hemoglobin molecule. b. Carbon dioxide is transported as part of the bicarbonate ion, as part of carbaminohemoglobin, and as a molecule dissolved in plasma.	Cont.
B		5. Breathing rate is controlled by respiratory centers in the medulla.	
A		6. Smoking can adversely affect the respiratory system and may result in: a. Lung cancer b. Emphysema	
C	Energy is released by the oxidation of organic compounds.	1. Cellular respiration involves three basic concepts. a. Hydrogen and its electron move from weak to progressively stronger electron acceptors. b. The transfer of hydrogen and its electron releases energy which can be used to form high energy bonds. c. Some energy is stored as ATP.	4%
B		2. Anaerobic respiration in muscle cells: a. Takes place in the absence of oxygen b. Results in the accumulation of lactic acid c. Produces low amounts of ATP	

PROGRAM COMPONENTS Cont.

PRIORITY RATING	CONCEPT		EMPHASIS IN PER CENT
B	Cont.	3. Aerobic respiration: a. Utilizes oxygen as a final electron acceptor b. Results in carbon dioxide and water as end products c. Produces high amounts or ATP	
A		4. ATP released during cellular respiration is utilized for several metabolic processes including: a. Synthesis b. Movement and muscle contraction c. Heat production d. Active transport	
A	The kidney provides homeostatic control over body fluids.	1. The excretory system removes metabolic wastes from the blood. a. Urea, formed in the liver, is a major nitrogenous waste product in the blood. b. The excretory system involves the kidney, ureter, urinary bladder, and urethra. c. Urine formation involves the glomerulus, Bowman's capsule, proximal and distal convoluted tubules, loop of Henle, and collecting duct.	8%
A		2. Body fluid balance is maintained by hormones and ions. a. Body fluid is regulated by aldosterone. b. Osmotic pressure of body fluids is regulated by antidiuretic hormone.	
A		3. Dialysis may replace kidney function.	

PROGRAM COMPONENTS Cont.

PRIORITY RATING	CONCEPT		EMPHASIS IN PER CENT
A	Regulation of internal environment requires co-ordination between the nervous and hormonal systems.	1. Endocrine secretions regulate and maintain body functions. a. Major endocrine glands include the pituitary, pancreas, adrenal and thyroid. b. Blood sugar regulation is influenced by insulin, adrenalin, thyroxin and glucagon. c. Hormone levels are regulated by negative feedback. d. Dwarfism is caused by a deficiency in human growth hormone.	16%
A		2. Nervous control involves reception, transmission, interpretation, and response. a. Stimuli in the environment must first be detected by sensory receptors. i. Eye. A. The cornea, iris, pupil, lens, and retina are involved in image formation. B. Light activates rods and cones. C. The optic nerve transmits images from the retina to the brain. D. Far- and near-sightedness and astigmatism are common disorders of the eye.	

PRIORITY RATING	CONCEPT		EMPHASIS IN PER CENT
		ii. Ear.	
		A. The eardrum, ossicles, round and oval windows, cochlear fluid, and the organ of corti are involved in sound transmission.	
		B. The auditory nerve transmits impulses from the cochlea to the brain.	
		C. The eustachian tube maintains equal pressure on both sides of the eardrum.	
	Cont.	D. The semicircular canals detect body position and motion.	
		iii. Chemoreceptors detect taste and odor.	
		iv. Receptors in the skin detect pressure and temperature.	
A		b. Neural transmission relays information throughout an organism.	
		i. Structure of a neutron.	
		ii. Electrical activity of a nerve impulse.	
		A. Threshold levels B. "All or none" response C. Refractory period	
		iii. Chemical transmission between neurons involves excitatory and inhibitory substances.	
		A. Acetylcholine B. Noradrenaline C. Acetylcholinesterase	

PRIO-RITY RATING	CONCEPT		EMPHASIS IN PER CENT
B	Cont.	c. The central nervous system interprets information and co-ordinates response. i. The cerebrum, hypothalamus, cerebellum, and medulla oblongata are major regions of the brain. ii. The spinal cord transmits information to and from the brain. iii. The reflex arc involves peripheral nerves and the spinal cord.	
B		d. The autonomic nervous system involves both sympathetic and parasympathetic nerves.	
B	Voluntary movement and body support are the result of skeletal muscles and the skeletons to which they are attached.	1. The skeleton provides for muscle attachment, protection, of internal organs and locomotion. a. Ligaments b. Tendons c. Joints	4%
B		2. Skeletal muscles have a unique structure. a. Fibers and fibrils. b. Actin and myosin.	
B		3. Muscle contraction is stimulated by nerve action.	
		4. Muscle contraction requires calcium, creatine phosphate, and ATP.	
		5. Inflammation of the joints may result in arthritis.	

PROGRAM COMPONENTS Cont.

PRIORITY RATING	CONCEPT		EMPHASIS IN PER CENT
B	Humans are capable of reproducing.	1. Reproduction systems: a. The male reproductive system involves the penis, scrotum, testicles, vas deferens, urethra, prostate gland, Cowper's gland, and the seminal vesicle. b. The female reproductive system involves the vagina, uterus, cervix, fallopian tubes, and ovaries.	8%
A		2. The development and functioning of the reproductive system is under the control of hormones. a. Gonadotropic hormones regulate the production of sex hormones. i. Follicle stimulating hormone ii. Lutenizing hormone iii. Intersticial cell stimulating hormone (male precursor) b. Testosterone functions in developing primary and secondary sex characteristics. c. Estrogen and progesterone function in: i. Developing primary and secondary sex characteristics ii. Menstrual cycle	
A		3. Pregnancy and child birth: a. Fertilization and implantation b. Pregnancy is maintained through a hormonal balance c. Embryonic and fetal development involves a placenta, the amnion, chorion, and the umbilical cord d. Oxytocin and relaxin are involved in the birth process	

GRADE 12
DIPLOMA EXAMINATION

Biology 30

June 1986

Alberta
EDUCATION

GRADE 12 DIPLOMA EXAMINATION
BIOLOGY 30

DESCRIPTION

Time: 2½ hours

Total possible marks: 100

This is a **CLOSED-BOOK** examination consisting of two parts:

PART A: 80 multiple-choice questions each with a value of 1 mark.

PART B: Six written-response questions for a total of 20 marks.

GENERAL INSTRUCTIONS

Fill in the information on the answer sheet as directed by the examiner.

For multiple-choice questions, read each carefully and decide which of the choices BEST completes the statement or answers the question. Locate that question number on the answer sheet and fill in the space that corresponds to your choice. USE AN HB PENCIL ONLY.

Example

This examination is for the subject area of

A. Chemistry
B. Biology
C. Physics
D. Mathematics

Answer Sheet

A	B	C	D
①	●	③	④

If you wish to change an answer, please erase your first mark completely.

For written-response questions, read each carefully, show all your calculations, and write your answer in the space provided in the examination booklet.

> NOTE: The perforated pages at the back of this booklet may be torn out and used for your rough work.

DO NOT FOLD EITHER THE ANSWER SHEET OR THE EXAMINATION BOOKLET

The presiding examiner will collect the answer sheet and examination booklet for transmission to Alberta Education.

JUNE 1986

PART A

INSTRUCTIONS

There are 80 multiple-choice questions with a value of one mark each in this section of the examination. Use the separate answer sheet provided and follow the specific instructions given.

NOTE: The perforated pages at the back of this booklet may be torn out and used for your rough work.

WHEN YOU HAVE COMPLETED PART A, PROCEED DIRECTLY TO PART B

DO NOT TURN THE PAGE TO START THE EXAMINATION UNTIL TOLD TO DO SO BY THE PRESIDING EXAMINER.

1. Mitochondria utilize large amounts of

A. oxygen
B. nitrogen
C. lactic acid
D. carbon dioxide

2. The organelles responsible for protein synthesis are the

A. lysosomes
B. ribosomes
C. mitochondria
D. Golgi bodies

3. A mutant strain of cells has abnormal mitochondria. The resulting deficiency in these cells would directly affect

A. energy production
B. alveolar gas exchange
C. intracellular transport
D. osmosis within blood capillaries

4. The greatest part of the mass of a living cell is made up of

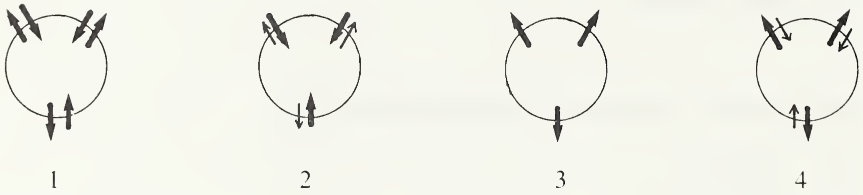
A. water
B. proteins
C. carbohydrates
D. organic molecules

5. In which activity would the human body NOT utilize ATP?

A. Digestion
B. Synthesis of hormones
C. Diffusion of water from interstitial fluid to capillaries
D. Movement of glucose molecules out of nephrons into interstitial fluid

Use the following information to answer question 6.

Red Blood Cells in Various Solutions



Note: Arrows indicate the movement of water in and out of red blood cells. The large arrows indicate a large volume of water, while the small arrows indicate a small volume of water.

6. If a red blood cell is placed in a concentrated salt solution, which of the above situations is likely to occur?

A. 1
B. 2
C. 3
D. 4

Use the following information to answer question 7.

Natural rubber is permeable to carbon dioxide, but impermeable to oxygen, nitrogen, and water vapor. Three natural rubber balloons were filled with equal volumes of gases. Balloon 1 was filled with CO_2, balloon 2 was filled with O_2, and balloon 3 was filled with exhaled breath. The balloons were released into a chamber filled with air and kept at a constant temperature and pressure.

7. What would be observed after two days?

A. Balloon 1 will have deflated more than balloon 3.
B. Balloon 3 will have deflated more than balloon 1.
C. Balloon 1 will have deflated as much as balloon 2.
D. Balloon 2 will have deflated as much as balloon 3.

---

8. Enzymes are always

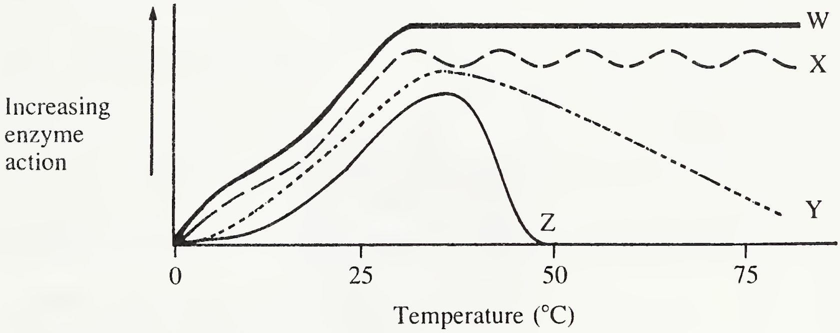
A. proteins
B. vitamins
C. phosphates
D. nucleic acids

9. Many insecticides interfere with metabolic reactions through the process of

A. exocytosis
B. endocytosis
C. active transport
D. competitive inhibition

Use the following information to answer question 10.

Lines W, X, Y and Z illustrate possible relationships between temperature and the rate of a reaction catalyzed by an enzyme.



10. In humans, the best illustration of the relationship is

A. W
B. X
C. Y
D. Z

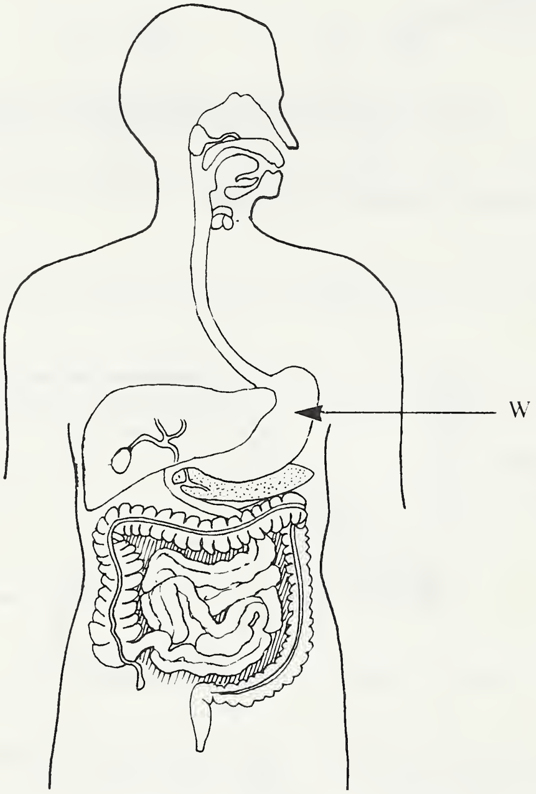
---

11. Nitrogen is a component of which nutrients?

A. Lipids and carbohydrates
B. Proteins and carbohydrates
C. Proteins and nucleic acids
D. Carbohydrates and nucleic acids

Use the following information to answer question 12.

Human Digestive System



12. The fluid produced in the organ labelled W would be

A. bile
B. insulin
C. gastric juice
D. pancreatic juice

Use the following information to answer question 13.

During an experiment, tests were performed on four foods to detect the presence of sugar, protein, starch, and lipid.

Test Tube	Food
1	butter
2	egg white
3	candy bar
4	potato

In one test, a substance was added to each test tube and then all test tubes were placed in a hot water bath. After 1 minute the contents of one of the test tubes had changed from a blue color to a reddish-orange color.

13. In which test tube did this color change occur?

A. 1
B. 2
C. 3
D. 4

---

14. The stomach contains enzymes which catalyze the chemical breakdown of

A. proteins under basic conditions
B. proteins under acidic conditions
C. carbohydrates under basic conditions
D. carbohydrates under acidic conditions

15. The function of the villi is to

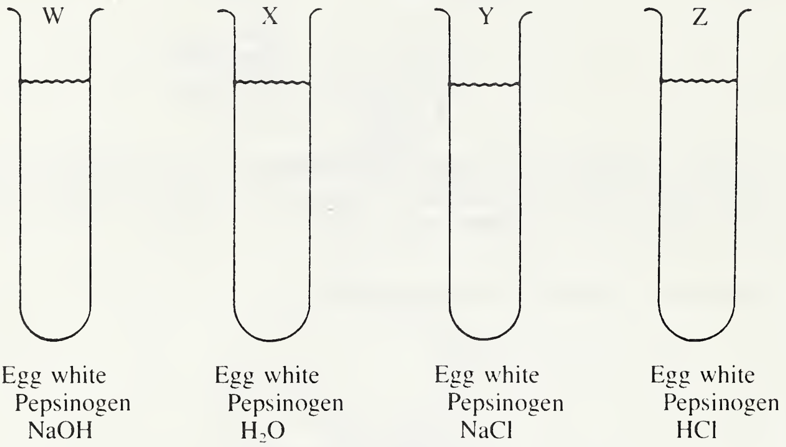
A. destroy bacteria
B. regulate digestion
C. move food along the intestine
D. increase the surface area of the small intestine

16. A person with a diseased gall bladder may experience difficulty

A. digesting fat
B. producing bile
C. storing glycogen
D. deaminating amino acids

Use the following information to answer question 17.

Equal amounts of egg white solution in four test tubes are incubated at 37°C for 45 minutes and then tested for degree of digestion.



17. The contents of the test tube that would indicate the greatest degree of digestion is

- **A.** W
- **B.** X
- **C.** Y
- **D.** Z

---

18. The organ which converts fatty acids into sugar is the

- **A.** small intestine
- **B.** pancreas
- **C.** stomach
- **D.** liver

19. Secretin plays an important role as one of the regulators of pH within the digestive system. The chief function of secretin is to stimulate the

A. liver to produce digestive enzymes
B. stomach to produce hydrochloric acid
C. pancreas to produce sodium bicarbonate
D. small intestine to produce digestive enzymes

20. An adult whose stomach fails to secrete hydrochloric acid will have difficulty in the initial digestion of

A. lipids
B. sugars
C. starches
D. proteins

21. The liberation of the contents of the gall bladder into the small intestine is required for the digestion of

A. fats
B. sugars
C. proteins
D. vitamins

22. Blood in the feces may indicate

A. damage to the nephric tubules
B. ulceration of the lining of the large intestine
C. excess absorption of proteins into the blood
D. destruction of the bone marrow by heavy metals

23. Before a disaccharide such as table sugar can be used in the human body, it must be converted to

A. two glycogen molecules
B. two disaccharide molecules
C. two monosaccharide molecules
D. one monosaccharide and one disaccharide molecule

24. The one-way flow of blood in the veins is assisted by BOTH

A. hormones and blood pressure
B. nervous control and endocrine control
C. valves and skeletal muscle contraction
D. blood pressure and the effects of acetylcholine

25. One laboratory procedure used to identify anemia, a disorder characterized by a lack of energy due to oxygen deficiency, is to take a

A. red blood cell count
B. blood pressure reading
C. white blood cell count
D. urine protein level measurement

26. Blood leaving the vena cava would proceed through the circulatory system in which order?

A. Left ventricle, left atrium, lung capillaries, right ventricle, right atrium
B. Right ventricle, right atrium, lung capillaries, left ventricle, left atrium
C. Left atrium, left ventricle, lung capillaries, right atrium, right ventricle
D. Right atrium, right ventricle, lung capillaries, left atrium, left ventricle

27. A function of the lymphatic system is to

A. return fluid to the blood
B. remove undigested wastes
C. return erythrocytes to the blood
D. produce erythrocytes and platelets

28. The chamber of the heart that has the thickest wall is the

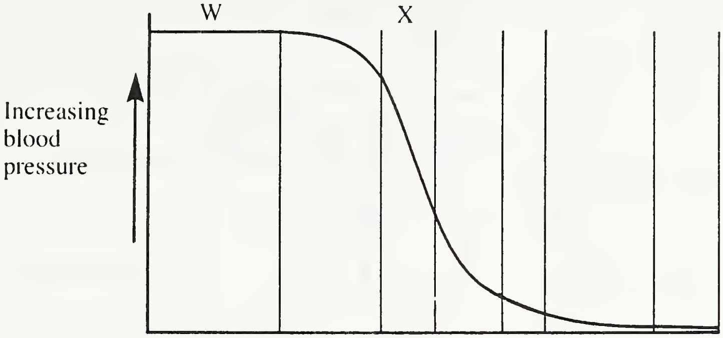
A. left atrium
B. right atrium
C. left ventricle
D. right ventricle

29. The pulse of blood that can be felt in the wrist and other parts of the body is the result of the

A. action of arterial valves
B. rhythmic functioning of valves in the veins
C. stretching and subsequent contracting of arterial walls
D. force of the contracting right ventricle transmitted through the blood

Use the following information to answer question 30.

Blood Pressure in Various Segments of the Human Circulatory System



Segments of the circulatory system

30. If graph segment W represents the pressure in the aorta, then graph segment X represents the pressure in

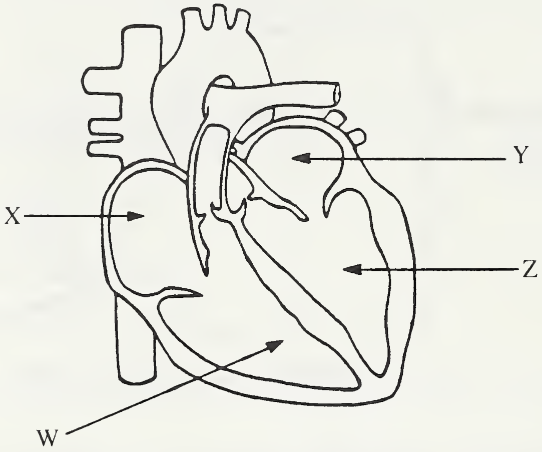
A. large veins
B. arterioles
C. arteries
D. venules

---

31. The heart ventricles begin to fill when

A. atrial pressure is lower than ventricular pressure and the atrioventricular (AV) valves are pushed open
B. ventricular pressure is lower than atrial pressure and the atrioventricular (AV) valves are pushed open
C. ventricular pressure is lower than atrial pressure and the atrioventricular (AV) valves are pushed shut
D. atrial pressure is lower than ventricular pressure and the atrioventricular (AV) valves are pushed shut

Use the following information to answer question 32.


Ventral View of the Human Heart

32. The chamber of the heart that receives blood directly from the pulmonary veins is

A. W
B. X
C. Y
D. Z

---

33. When blood pressure exceeds the osmotic pressure in the capillaries, the net movement of H_2O is

A. into the tissues
B. into the capillaries
C. unchanged because of the relatively impermeable capillary wall
D. unchanged because of the immediate increase in osmotic pressure

34. Four individuals, W, X, Y and Z, were interested in their blood types. Individual Z knew that she was of type O. The blood type of one of the other individuals could be definitely determined when

A. Z's serum clumped the red blood cells in a sample of X's blood
B. X's serum clumped the red blood cells in a sample of Y's blood
C. Z's serum did not clump the red blood cells in a sample of W's blood
D. X's serum did not clump the red blood cells in a sample of W's blood

Use the following information to answer question 35.

Skin capillaries were observed microscopically. Each of 10 capillaries was subjected to the series of treatments outlined below. Each capillary was allowed to recover from the effects of one treatment before being subjected to the next.

	Treatment	Average flow of blood cells/minute
I	none (normal)	600
II	adrenalin added	400
III	alcohol added	800
IV	lactic acid added	900
V	temperature reduced	300

35. Treatment II was repeated using a slightly higher concentration of adrenalin. With reference to the original treatment of adrenalin, the increased concentration of adrenalin would probably

A. cause a decrease in the blood cell flow
B. cause an increase in the blood cell flow
C. result in a change comparable to Treatment IV
D. result in a change comparable to Treatment III

---

36. In airline emergencies at high altitudes, oxygen masks are used by passengers. Why is a small amount of carbon dioxide added to the oxygen?

A. Carbon dioxide is necessary to reduce the hemoglobin.
B. Pure oxygen cannot be absorbed by the lungs unless diluted.
C. Carbon dioxide stimulates the respiratory centre in the brain.
D. Pure oxygen causes the formation of nitrogen bubbles in the blood.

37. The function of the alveoli of the lungs is to

A. filter harmful bacteria out of the air
B. actively transport oxygen into the capillaries
C. provide a large surface area for gas exchange
D. provide a surface for cellular respiration to occur

38. A person starts a two-year training program in an attempt to become a marathon runner. It would be reasonable to predict that at the end of the two-year training period the person at rest would have a

A. faster breathing rate and a faster heart rate
B. slower breathing rate but a faster heart rate
C. faster breathing rate but a slower heart rate
D. slower breathing rate and a slower heart rate

39. Emphysema is characterized by the destruction of some of the alveolar walls in the lungs. Which statement describes a person suffering from emphysema?

A. A decreased alveolar surface area and a decreased CO_2 content of the blood
B. A decreased alveolar surface area and an increased CO_2 content of the blood
C. An increased alveolar surface area and a decreased CO_2 content of the blood
D. An increased alveolar surface area and an increased CO_2 content of the blood

40. When a mountain climber ascends to about 3700 m, he may experience headaches and nausea. After a month at high altitudes, these effects wear off because

A. he has now adapted to use less oxygen
B. the number of red blood cells has increased
C. carbon dioxide begins to diffuse faster from the lungs
D. the alveolar surface area has increased to receive more oxygen

41. A high carbon dioxide level in the blood would decrease the pH of the blood by forming carbonic acid. This low pH is avoided because

A. H^+ combines with hemoglobin
B. H^+ forms from bicarbonate ions
C. enzymes prevent excess H^+ formation
D. oxyhemoglobin can raise the pH of the blood

42. Electrons are transferred from weak to stronger acceptors. An example of an electron acceptor is

A. ATP
B. oxygen
C. glucose
D. lactic acid

43. To maintain constant internal body temperature under low external temperatures, the type of tissue that produces heat is

A. fat
B. blood
C. muscle
D. epithelial

44. If cellular respiration stopped, which activity would be affected first?

A. Osmosis
B. Diffusion
C. Active transport
D. Molecular motion

45. After a period of strenuous exercise is over, the breathing rate continues at a higher level for a number of minutes because more oxygen is required to

A. lower the pH in muscle and blood tissue
B. metabolize lactic acid and restore ATP levels
C. reduce creatine phosphate in muscle tissue to normal levels
D. neutralize carbon dioxide levels in the blood and muscle tissue

46. Amino acids move from the glomerulus to Bowman's capsule because of

A. diffusion
B. endocytosis
C. blood pressure
D. active transport

47. Blood enters the kidney through the

A. aorta
B. vena cava
C. renal vein
D. renal artery

48. Production of urea results primarily from the metabolism of

A. fats
B. amino acids
C. nucleic acids
D. carbohydrates

49. Between the proximal tubule and the loop of Henle the change in glucose concentration is due to

A. osmosis
B. filtration
C. exocytosis
D. reabsorption

50. The correct sequence of structures through which a molecule of urea would pass is

A. Bowman's capsule → glomerulus → tubules and loop of Henle → ureter → collecting duct → bladder → urethra
B. glomerulus → Bowman's capsule → tubules and loop of Henle → collecting duct → urethra → bladder → ureter
C. Bowman's capsule → glomerulus → tubules and loop of Henle → collecting duct → ureter → bladder → urethra
D. glomerulus → Bowman's capsule → tubules and loop of Henle → collecting duct → ureter → bladder → urethra

51. Which statement best expresses the relationship between ADH levels in the blood and the formation of concentrated or dilute urine?

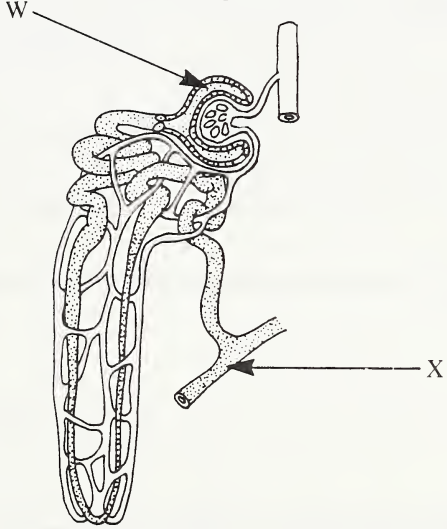
A. Low levels of ADH result in the production of concentrated urine.
B. High levels of ADH result in the production of concentrated urine.
C. Low levels of ADH result in greater reabsorption of water by the blood.
D. High levels of ADH result in greater reabsorption of salt by distal tubules.

52. Diabetes insipidus is a disease that results in an excessive volume of highly dilute urine. This is probably due to

A. low TSH levels
B. low ADH levels
C. high TSH levels
D. high ADH levels

Use the following information to answer question 53.

Human Nephron



53. If the concentration of a substance is 0.01 g/L in the structure labelled W and 0.10 g/L in the structure labelled X, then the substance is probably

A. retained in the blood
B. reabsorbed by tubule cells
C. not reabsorbed by tubule cells
D. returned to the circulatory system

54. Nervous system function is supplemented by the actions of the

A. excretory system
B. endocrine system
C. respiratory system
D. circulatory system

55. The presence of adrenalin in the blood would result in

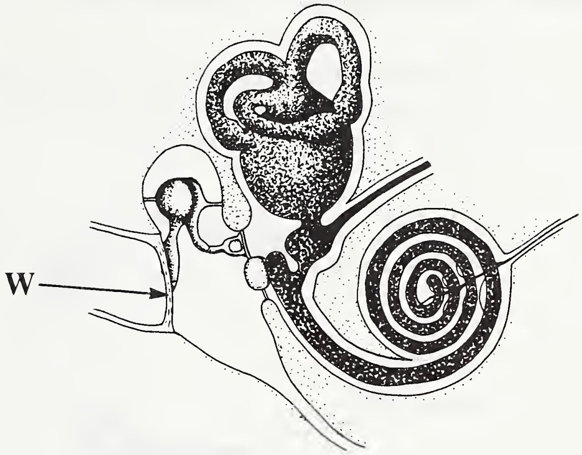
A. increased blood flow to digestive organs
B. increased blood flow to skeletal muscles
C. a decrease in the conversion rate of glycogen to glucose
D. a decrease in heart rate and strength of heart contraction

56. A color-blind person's eyes would have defective

A. rods
B. cones
C. foveas
D. optic nerves

Use the following information to answer question 57.

The Human Ear



57. The structure labelled W represents the

A. utricle
B. cochlea
C. ossicles
D. ear drum

---

58. Nervous co-ordination differs from hormonal co-ordination because nervous co-ordination is

A. faster
B. slower
C. less specific
D. controlled by hormones

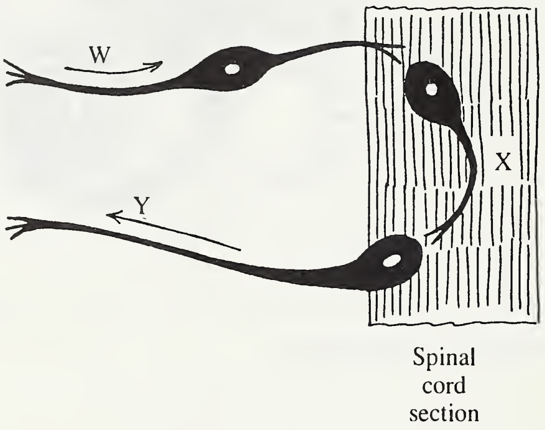
59. Cholinesterase, which is released at the synapse, is inactivated by a poison. This poisoning will result in

A. increased permeability of the dendrite
B. decreased permeability of the dendrite
C. continued action of the transmitter substance
D. complete inactivation of the transmitter substance

60. The autonomic nervous system has minimal, if any, control of

A. dilation of the pupils to read this statement
B. decreased intestinal peristalsis due to stress
C. exam tension causing increased gastric secretion
D. muscular co-ordination required to write this exam

Use the following information to answer question 61.



A Neural Pathway

61. Which label in the diagram identifies a sensory neuron or neurons?

A. Y only
B. W only
C. Y and X
D. W and X

---

62. The process involved in changing the shape of the lens while viewing objects at varying distances is

A. adaptation
B. astigmatism
C. accommodation
D. depth perception

63. A body response that can be attributed to the action of thyroxin is

A. increased heart rate after an accident
B. increased blood glucose after exercise
C. decreased skin blood supply during bleeding
D. increased body heat production in cold weather

64. The refractory period of a neuron was found to be 0.001 seconds. The neuron was stimulated at the threshold level and 0.0002 seconds later it was again stimulated at the threshold level. The second stimulus would

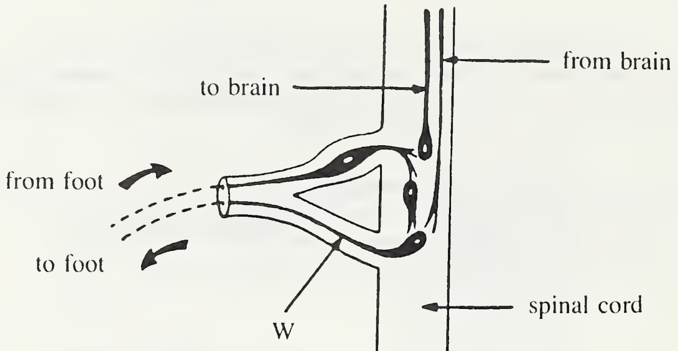
A. produce an impulse in the neuron
B. not produce an impulse in the neuron
C. cause the speed of the impulse to slow down
D. cause the neuron to take a longer period to recover

65. The pathway for the transmission of sound in the ear is

A. tympanic membrane, oval window, ossicles, cochlea, hair cells, auditory nerve
B. auditory canal, tympanic membrane, ossicles, oval window, hair cells, auditory nerve
C. tympanic membrane, Eustachian tube, ossicles, cochlea, oval window, hair cells, auditory nerve
D. auditory canal, Eustachian tube, tympanic membrane, ossicles, oval window, hair cells, auditory nerve

Use the following information to answer question 66.

Motor and Sensory Pathways From Foot to Brain



A barefoot person by a campfire accidentally steps on a hot coal and then feels the sharp pain of the burn.

66. If there had been a blockage at point W prior to the accident, the person would have felt

A. pain and could have moved his foot
B. no pain and could have moved his foot
C. pain and would not have been able to move his foot
D. no pain and would not have been able to move his foot

67. If temperature receptors in the hypothalamus sense that the blood is too warm

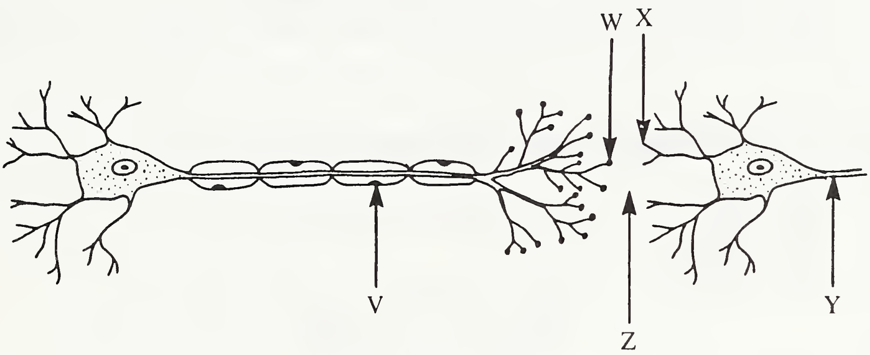
A. skin arterioles dilate
B. skin arterioles constrict
C. the pancreas increases the secretion of glucagon
D. the thyroid gland increases the rate of metabolism

68. The effects of the sympathetic nervous system are similar to those of

A. adrenalin
B. conditioning
C. acetylcholine
D. accommodation

Use the following information to answer question 69.

Human Neurons



69. During an experiment it was found that an impulse travelled from V to W but not from W to Y. Which of the following is a likely reason to explain the non-transmission from W to Y?

A. There is an excess of acetylcholine at Z.
B. A drug may be inhibiting cholinesterase at Z.
C. The depolarization mechanism is non-functional at X.
D. A drug may be stimulating the action of a neurotransmitter at W.

70. Myofibrils are made up of protein filaments consisting of

A. actin and myelin
B. myosin and actin
C. ATP and rhodopsin
D. myosin and collagen

71. When a muscle becomes fatigued, there is

A. no glycogen, little lactic acid, and much ATP in the muscle
B. little lactic acid, little ATP, and much glycogen in the muscle
C. much lactic acid, much ATP, and much glycogen in the muscle
D. little or no ATP, little glycogen, and much lactic acid in the muscle

72. During muscle contraction, creatine phosphate functions by

A. acting in place of ATP in muscle fibre contraction
B. hydrolyzing glycogen to begin cellular respiration
C. adding phosphate to glucose to begin fermentation
D. providing high energy phosphate for the synthesis of ATP

73. The thickening of the uterine wall is caused mainly by

A. LH
B. FSH
C. estrogen
D. oxytocin

74. An ovum develops within

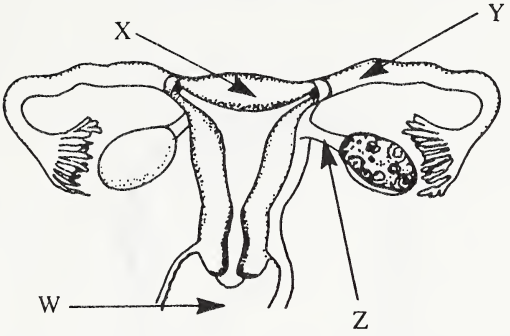
A. an ovary that is within a follicle
B. a follicle that is within an ovary
C. a corpus luteum that is within an ovary
D. a corpus luteum that is within a follicle

75. If the supply of testosterone in a normal human male were stopped, one would expect an INCREASE in the secretion of

A. relaxin
B. adrenalin
C. aldosterone
D. gonadotropic hormone

Use the following information to answer question 76.

The Female Reproductive System

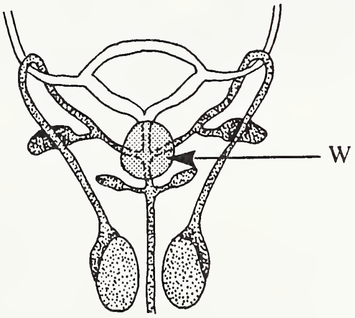


76. The structure through which eggs pass from ovary to uterus is labelled

A. W
B. X
C. Y
D. Z

Use the following information to answer question 77.

The Male Urogenital System

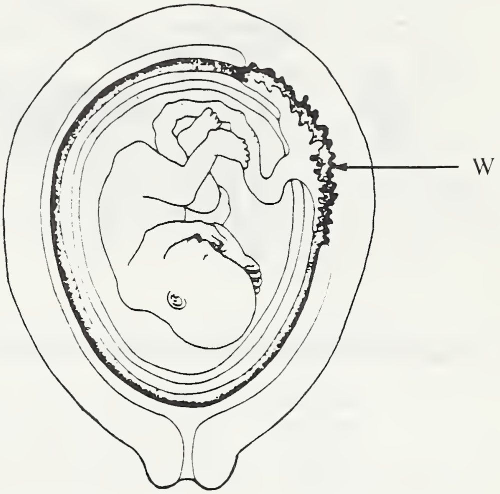


77. The structure labelled W is the

A. bladder
B. prostate gland
C. seminal vesicle
D. Cowper's gland

Use the following information to answer question 78.

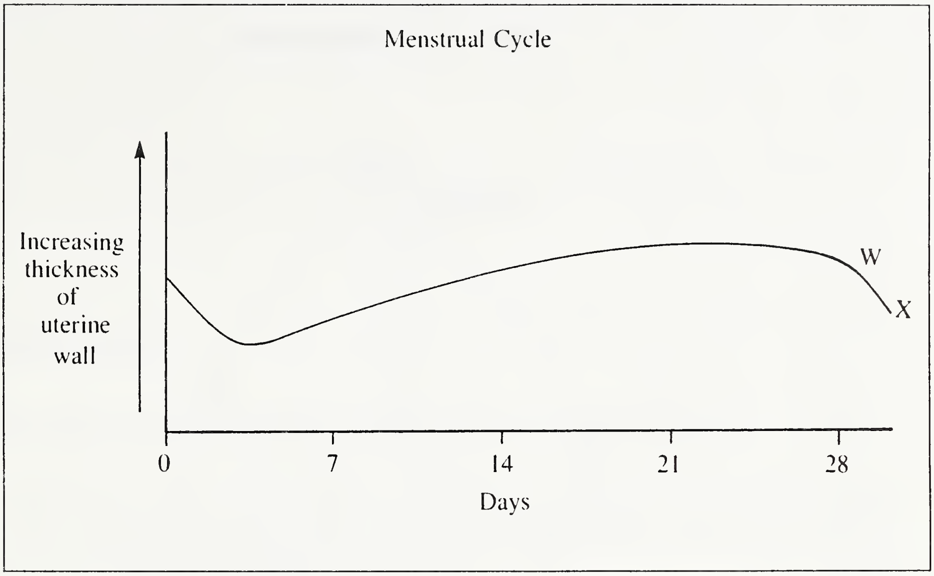
Human Fetus



78. The structure labelled W functions to

A. form blood cells
B. produce amniotic fluid
C. produce food for the fetus
D. exchange nutrients and wastes

Use the following information to answer question 79.

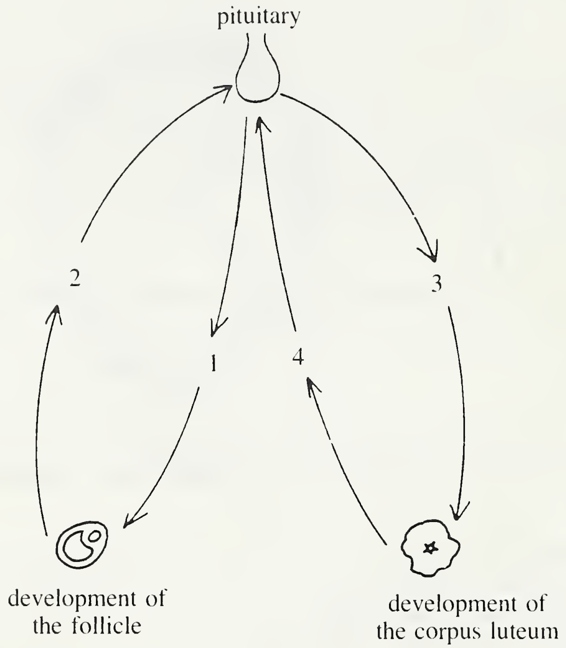


79. In the graph, the curve from W to X represents what happens in the menstrual cycle when

A. estrogen increases
B. progesterone decreases
C. the uterine lining thickens
D. the corpus luteum secretes LH

Use the following information to answer question 80.

A Hormonal Feedback System



80. The hormone represented by number 1 is

A. LH
B. FSH
C. estrogen
D. progesterone

YOU HAVE NOW COMPLETED THE MULTIPLE-CHOICE SECTION OF THE EXAMINATION. PLEASE PROCEED TO THE NEXT PAGE AND ANSWER THE WRITTEN-RESPONSE QUESTIONS IN PART B.

PART B

INSTRUCTIONS

Please write your answers in the examination booklet as neatly as possible.

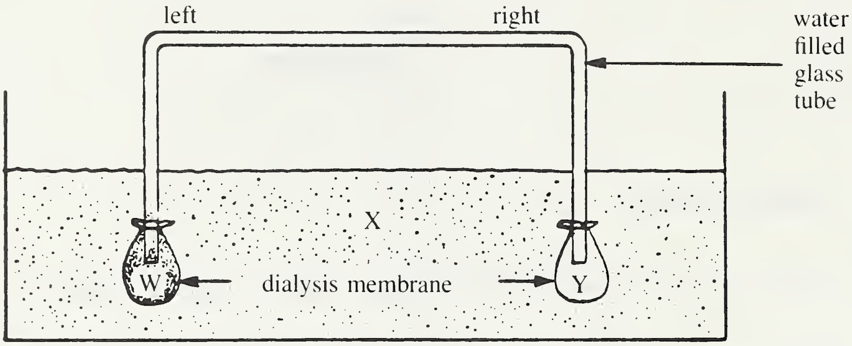
NOTE: The perforated pages at the back of this booklet may be torn out and used for your rough work.

TOTAL MARKS: 20

START PART B IMMEDIATELY

Use the following information to answer question 1.

An Osmotic System



W represents a 6% glucose solution
X represents a 3% glucose solution
Y represents a 1% glucose solution

Note: the membranes at W and Y are impermeable to glucose.

(1 mark) **1.** **a.** Initially, in which direction would the solution in the tube move?

(2 marks) **b.** Explain your answer.

(6 marks) **2.** Using materials from the list below, design a PROCEDURE for a demonstration to show which substance (starch or glucose) passes more quickly through a semipermeable membrane. Assume that any other necessary lab equipment is available.

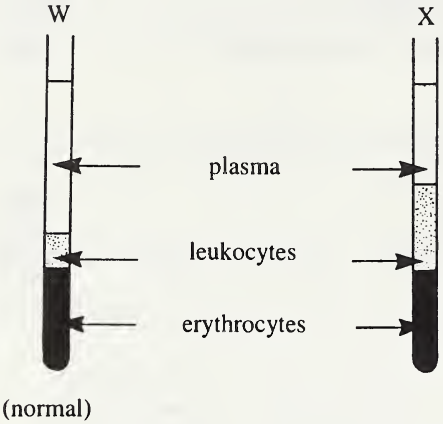
Materials:

1% glucose solution
1% starch suspension
dialysis tubing (semipermeable membrane)
Benedict's solution
iodine solution
distilled water

(2 marks) **3.** Insulin is composed of a large number of amino acids chemically bonded together. Given this information, why must a diabetic inject insulin rather than take it orally?

Use the following information to answer question 4.

When blood from subjects W and X is mixed with an anticoagulant and centrifuged, it separates into erythrocytes, leukocytes, and plasma components. The diagram below represents blood samples taken from the two subjects living at sea level.



(2 marks) 4. a. Compare the differences in cellular composition of the two blood samples from W and X and give a plausible interpretation for the blood composition of subject X.

(2 marks) b. Hemoglobin has a much greater affinity for carbon monoxide than for oxygen. If subject W were exposed to low levels of carbon monoxide for one month, what change would you expect to find in a blood sample taken at the end of this period? Explain your answer.

Use the following information to answer question 5.

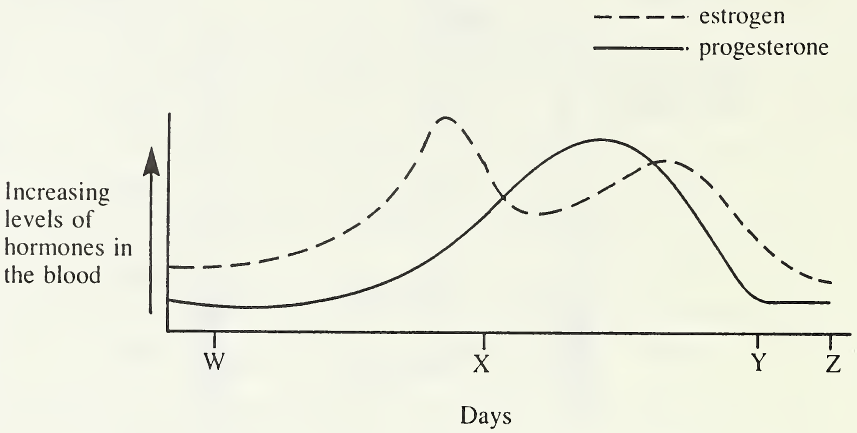
Daily Water Loss in Humans		
Medium	Water Loss Without Exercise (mL)	Water Loss With Exercise (mL)
Water Vapor (from lungs)	350	850
Sweat	450	2900
Feces	200	200
Urine	1400	500
TOTAL	2400	4450

(2 marks) 5. a. In reference to the data, explain why there is increased water loss through the lungs and skin during prolonged exercise.

(1 mark) **b.** Indicate why daily urine output decreases during a period of heavy exercise.

Use the following information to answer question 6.

Estrogen and Progesterone Levels During A Menstrual Cycle



(1 mark) 6. a. By which day (W, X, Y or Z) would you expect to find a functioning corpus luteum?

____

(1 mark) b. Explain your answer.

____

____

____

____

YOU HAVE NOW COMPLETED THE EXAMINATION. IF YOU HAVE TIME, YOU MAY WISH TO GO BACK AND CHECK YOUR ANSWERS.

BIOLOGY 30 MULTIPLE-CHOICE KEY

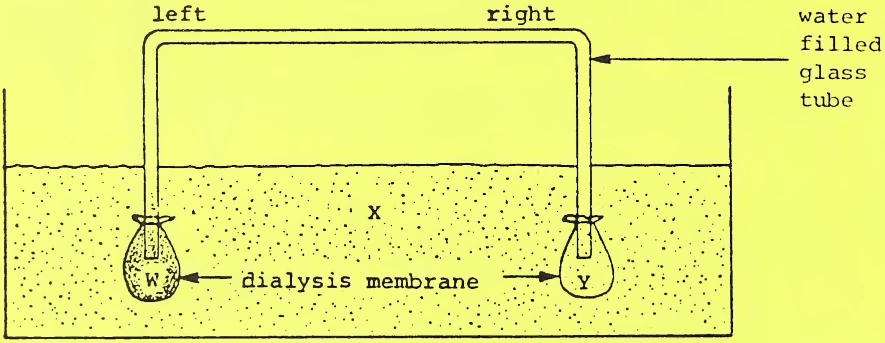
1.	A	41.	A
2.	B	42.	B
3.	A	43.	C
4.	A	44.	C
5.	C	45.	B
6.	D	46.	C
7.	A	47.	D
8.	A	48.	B
9.	D	49.	D
10.	D	50.	D
11.	C	51.	B
12.	C	52.	B
13.	C	53.	C
14.	B	54.	B
15.	D	55.	B
16.	A	56.	B
17.	D	57.	D
18.	D	58.	A
19.	C	59.	C
20.	D	60.	D
21.	A	61.	B
22.	B	62.	C
23.	C	63.	D
24.	C	64.	B
25.	A	65.	B
26.	D	66.	C
27.	A	67.	A
28.	C	68.	A
29.	C	69.	C
30.	B	70.	B
31.	B	71.	D
32.	C	72.	D
33.	A	73.	C
34.	C	74.	B
35.	A	75.	D
36.	C	76.	C
37.	C	77.	B
38.	D	78.	D
39.	B	79.	B
40.	B	80.	B

SAMPLE ANSWERS TO THE WRITTEN-RESPONSE SECTION

Note: The responses that follow represent ONE approach to each of the problems. During the diploma examination marking session, provision is made for considering the various approaches students may have used.

Use the following information to answer question 1.

An Osmotic System



W represents a 6% glucose solution
X represents a 3% glucose solution
Y represents a 1% glucose solution

Note: the membranes at W and Y are impermeable to glucose.

(1 mark) 1. a. Initially, in which direction would the solution in the tube move?

- from left to right

(2 marks) b. Explain your answer.

- the net movement of water is from X to W because W has a greater concentration of glucose

- the net movement of water is from Y to X because X has a greater concentration of glucose

(6 marks) 2. Using materials from the list below, design a PROCEDURE for a demonstration to show which substance (starch or glucose) passes more quickly through a semipermeable membrane. Assume that any other necessary lab equipment is available.

Materials:

1% glucose solution
1% starch suspension
dialysis tubing (semipermeable membrane)

Benedict's solution
iodine solution
distilled water

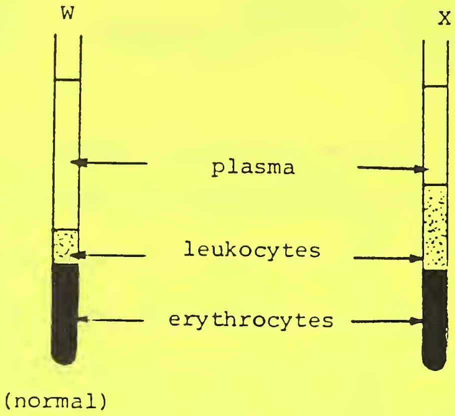
- put glucose in dialysis tubing to form a bag
- put starch in dialysis tubing to form a bag
- place dialysis bag(s) in a beaker(s) of distilled H_2O.
- test for the presence of starch with iodine
- test for the presence of glucose with Benedict's solution.
- tests should be taken at regular time intervals in order to determine which substance (starch or glucose) passes through the membrane most quickly.

(2 marks) 3. Insulin is composed of a large number of amino acids chemically bonded together. Given this information, why must a diabetic inject insulin rather than take it orally?

- insulin is a protein
- the protein would be digested

Use the following information to answer question 4.

When blood from subjects W and X is mixed with an anticoagulant and centrifuged, it separates into erythrocytes, leukocytes, and plasma components. The diagram below represents blood samples taken from the two subjects living at sea level.



(2 marks) 4. a. Compare the differences in cellular composition of the two blood samples from W and X and give a plausible interpretation for the blood composition of subject X.

- subject X has a greater volume of leukocytes
- subject X may have an infection

(2 marks) b. Hemoglobin has a much greater affinity for carbon monoxide than for oxygen. If subject W were exposed to low levels of carbon monoxide for one month, what change would you expect to find in a blood sample taken at the end of this period? Explain your answer.

- increased volume of erythrocytes
- due to reduced O_2 levels in the blood

Use the following information to answer question 5.

Daily Water Loss in Humans		
Medium	Water Loss Without Exercise (mL)	Water Loss With Exercise (mL)
Water Vapour (from lungs)	350	850
Sweat	450	2900
Feces	200	200
Urine	1400	500
TOTAL	2400	4450

(2 marks) 5. a. In reference to the data, explain why there is increased water loss through the lungs and skin during prolonged exercise.

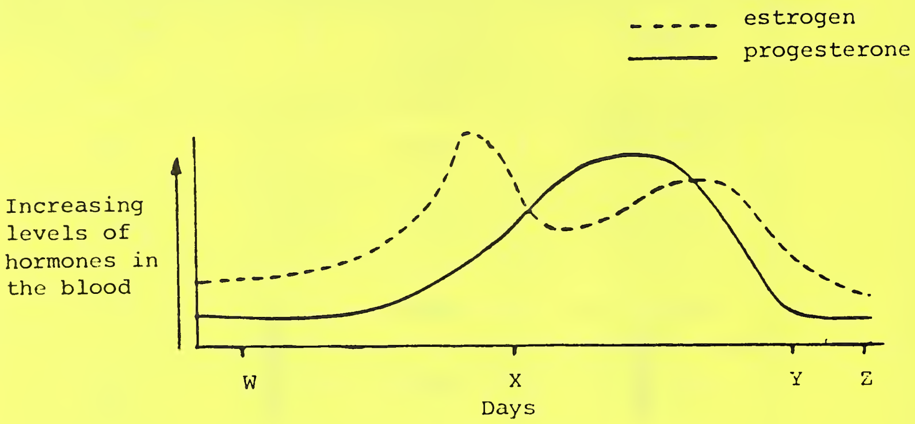
- breathing (rate and depth) increases during exercise which results in increased water loss through the lungs
- to cool the body by means of increased perspiration

(1 mark) b. Indicate why daily urine output decreases during a period of heavy exercise.

- to compensate for the high loss of water.

Use the following information to answer question 6.

Estrogen and Progesterone Levels During A Menstrual Cycle



(1 mark) 6. a. By which day (W, X, Y or Z) would you expect to find a functioning corpus luteum?

- X

(1 mark) b. Explain your answer.

- an increasing progesterone level indicates that the corpus luteum is functioning

GRADE 12
DIPLOMA EXAMINATION

Biology 30

January 1986

Alberta
EDUCATION

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GRADE 12 DIPLOMA EXAMINATION
BIOLOGY 30

DESCRIPTION

Time: 2½ hours

Total possible marks: 100

This is a **CLOSED-BOOK** examination consisting of two parts:

PART A: 80 multiple-choice questions each with a value of 1 mark.

PART B: Nine written-response questions for a total of 20 marks.

GENERAL INSTRUCTIONS

Fill in the information on the answer sheet as directed by the examiner.
For multiple-choice questions, read each carefully and decide which of the choices BEST completes the statement or answers the question. Locate that question number on the answer sheet and fill in the space that corresponds to your choice. USE AN HB PENCIL ONLY.

Example

This examination is for the subject area of

A. Chemistry
B. Biology
C. Physics
D. Mathematics

Answer Sheet

A	B	C	D
①	●	③	④

If you wish to change an answer, please erase your first mark completely.

For written-response questions, read each carefully, show all your calculations, and write your answer in the space provided in the examination booklet.

> NOTE: The perforated pages at the back of this booklet may be torn out and used for your rough work.

DO NOT FOLD EITHER THE ANSWER SHEET OR THE EXAMINATION BOOKLET

The presiding examiner will collect the answer sheet and examination booklet for transmission to Alberta Education.

JANUARY 1986

PART A

INSTRUCTIONS

There are 80 multiple-choice questions with a value of one mark each in this section of the examination. Use the separate answer sheet provided and follow the specific instructions given.

NOTE: The perforated pages at the back of this booklet may be torn out and used for your rough work.

WHEN YOU HAVE COMPLETED PART A, PROCEED DIRECTLY TO PART B

DO NOT TURN THE PAGE TO START THE EXAMINATION UNTIL TOLD TO DO SO BY THE PRESIDING EXAMINER.

1. A cell membrane is composed of

   A. fatty acids
   B. amino acids
   C. carbohydrates and proteins
   D. fatty substances and proteins

2. A function of the cell membrane is to

   A. synthesize cellular secretions
   B. generate energy for use in the cell
   C. regulate what enters and leaves the cell
   D. provide a surface area for chemical reactions

3. A process by which large particles are engulfed by cells is

   A. diffusion
   B. exocytosis
   C. endocytosis
   D. passive transport

4. Cytoplasm of human brain cells was tested for certain organic compounds. In which of the series below would ALL three tests show positive results?

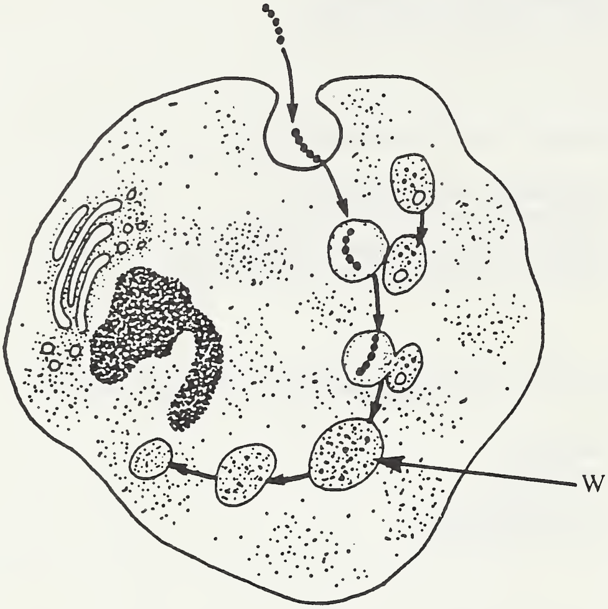
   A. Biuret, Sudan IV, and starch test
   B. Biuret, Sudan IV, and iodine test
   C. Biuret, translucence, and starch test
   D. Biuret, Sudan IV, and Benedict's test

5. What will happen when a sac made of a semi-permeable membrane filled with glycerol is suspended in a beaker of distilled water? There will

   A. be a net movement of water into the bag
   B. not be any movement of glycerol or water
   C. be a net movement of water out of the bag by osmosis
   D. be a net movement of glycerol out of the bag by osmosis

Use the following information to answer question 6.

A Functioning White Blood Cell

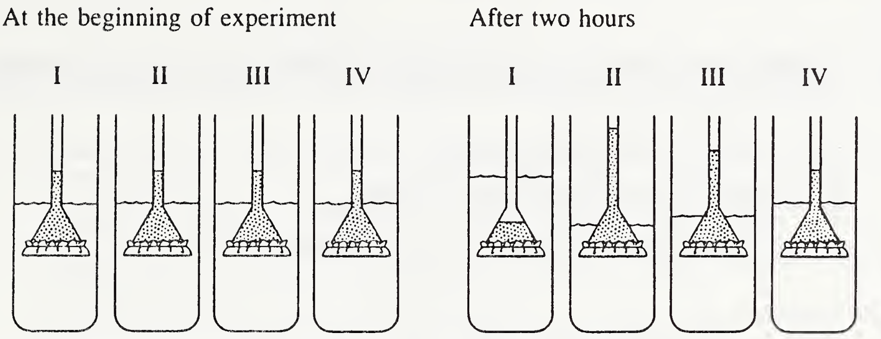


6. Which cytoplasmic organelle is responsible for the occurrence of the activities within W?

   A. Ribosome
   B. Lysosome
   C. Mitochondrion
   D. Golgi apparatus

Use the following information to answer question 7.

Four funnels are partially filled with various concentrations of a sugar solution and sealed with membranes that are impermeable to sugar and permeable to water. The funnels are then placed in beakers containing an initial 1% sugar solution and left for two hours.



7. Which funnel contained a 1% solution of sugar?

A. I
B. II
C. III
D. IV

---

8. Enzymes alter the rate of a reaction by

A. decreasing the activation energy
B. increasing the activation energy
C. decreasing the amount of substrate
D. increasing the amount of substrate

9. Stress creates an abnormal increase of substance X in the body. Homeostasis may be maintained by

A. decreasing production of X
B. increasing production of X
C. producing X at a steady rate
D. effecting no change in the production of X

10. A poison inhibits the activity of an enzyme involved in the breakdown of glucose in a cell. The poison may act by

A. reducing the energy of activation
B. occupying the active site of the enzyme
C. altering the shape of the glucose molecules
D. increasing electron transfer in the mitochondria

11. The structure that usually ensures that food will pass directly into the digestive tube and not into the trachea is the

A. larynx
B. pharynx
C. epiglottis
D. esophagus

12. Products of carbohydrate digestion are absorbed mainly in the

A. stomach
B. pancreas
C. large intestine
D. small intestine

13. The organ that removes many substances from the blood is the

A. liver
B. heart
C. pancreas
D. gall bladder

14. Peristalsis in the esophagus is stimulated by

A. hormones
B. lack of food
C. presence of food
D. decrease in production of salivary amylase

15. Which situation provides the BEST evidence to support the prediction ‘‘Secretion of enzymes from the pancreas is under nervous control?’’

A. If there is no food in the stomach or small intestine of a dog, the pancreas will not secrete enzymes.
B. If the nerves leading to the pancreas of a hungry dog are cut, no enzymes are secreted by the pancreas.
C. When the nerves leading to the pancreas of a dog are cut and weak acid is placed in the intestine, the pancreas secretes enzymes.
D. When the circulatory systems of two dogs are connected and food is placed in the intestine of one dog, the pancreas in both dogs secrete enzymes.

16. One symptom of diabetes mellitus is the presence of sugar in the urine. Which reagent would assist in diagnosing this condition?

A. Sudan IV dye
B. Biuret reagent
C. Iodine solution
D. Benedict’s solution

17. If a human is deprived of food for a long time, in which order are the energy reserves of the body normally utilized?

A. Fats, carbohydrates, proteins
B. Carbohydrates, fats, proteins
C. Carbohydrates, proteins, fats
D. Proteins, carbohydrates, fats

18. If an athlete needs a quick energy source, the best source would be

A. fat
B. protein
C. vitamins
D. carbohydrates

Use the following information to answer question 19.

Protein Digestion

$$\text{Protein} + \boxed{V} \xrightarrow[]{\substack{\text{Stomach enzyme } \mathbf{W} \\ \text{and} \\ \text{Substance } \mathbf{Z} \text{ from stomach}}} \boxed{X} + \boxed{Y}$$

19. Substance W could most likely be

A. gastrin
B. secretin
C. pepsinogen
D. hydrochloric acid

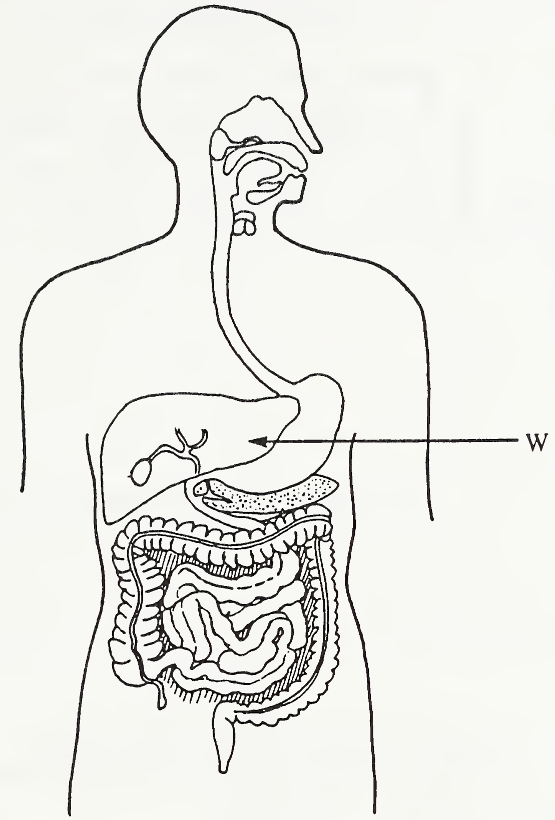
---

20. The primary reason that a low concentration of carbohydrates is normally found in cytoplasm is because carbohydrates are

A. fat soluble
B. used as a source of energy
C. the building blocks of protein
D. the building blocks of plasma membranes

Use the following information to answer question 21.

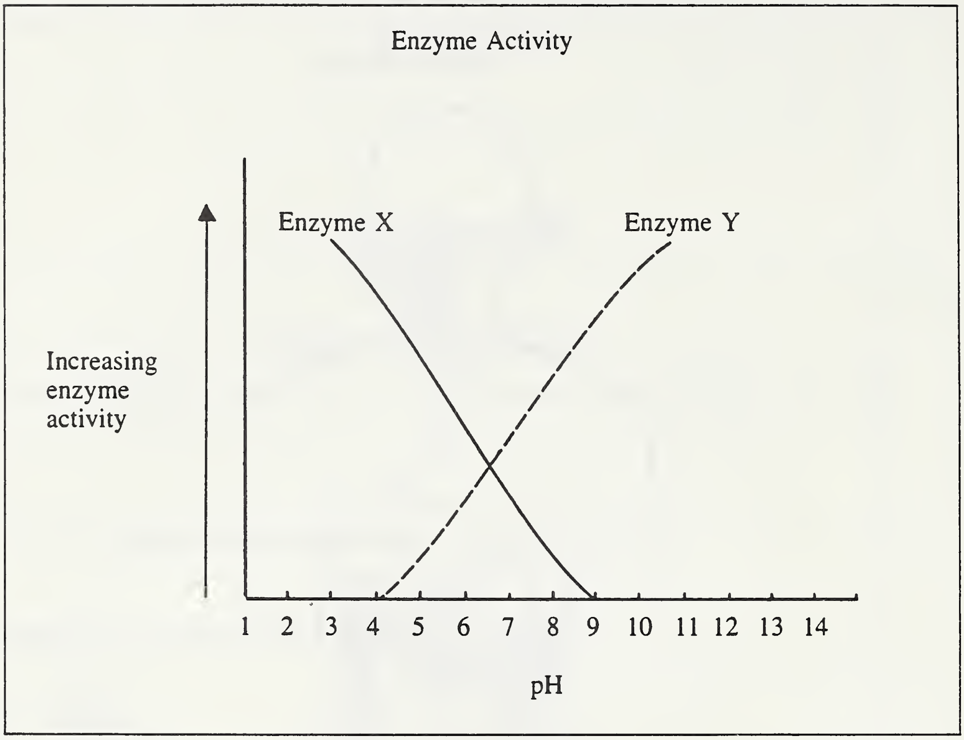
Digestive System



21. Organ W has many functions. The function directly related to digestion is the

A. production of bile
B. storage of vitamins
C. deamination of amino acids
D. maintenance of glucose levels in blood

Use the following information to answer question 22.



22. The digestion of protein is initiated by the enzyme labelled

A. Y, which works best in the stomach
B. X, which works best in the stomach
C. X, which works best in the small intestine
D. Y, which works best in the small intestine

Use the following information to answer question 23.

Test tube 1 contains vegetable oil.

Test tube 2 contains egg-white.

Test tube 3 contains a glucose solution.

Test tube 4 contains cornstarch.

23. A small amount of gastric juice is added to each of the four test tubes. After the test tubes are incubated for four hours at body temperature, the digestive process will be MOST advanced in the contents of test tube

A. 1
B. 2
C. 3
D. 4

---

24. Contraction of the left ventricle normally forces blood into the

A. aorta
B. left atrium
C. pulmonary vein
D. pulmonary artery

25. A homeostatic response to a decline in blood pressure would be a

A. vasodilation
B. vasoconstriction
C. decline in heart rate
D. decrease in aortic pressure

26. Blood returns to the heart from the lower body through the

A. aorta
B. pulmonary vein
C. inferior vena cava
D. superior vena cava

27. Leukocytes are important in the

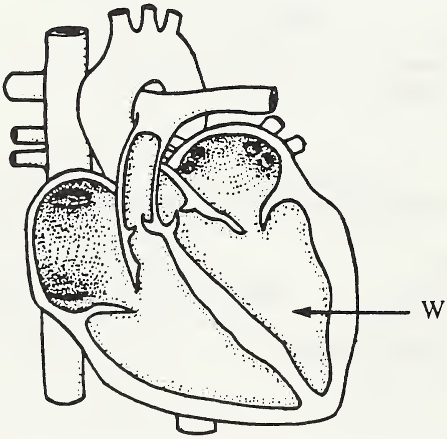
A. formation of antibodies
B. formation of red blood cells
C. engulfing and digesting of food particles
D. transportation of carbon dioxide in the blood

28. A stroke may be caused by a blockage of a blood vessel in the

A. brain
B. heart
C. coronary artery
D. pulmonary artery

Use the following information to answer question 29.

The Human Heart



29. Blood passing through the structure marked W is

A. oxygenated
B. deoxygenated
C. going to the lungs
D. coming from the body

Use the following information to answer question 30.

Events in Heart Contractions Listed in Random Order

1. Semilunar valves open
2. Atrioventricular valves close
3. Atrial contraction begins
4. Ventricular contraction begins

30. Which sequence correctly describes the series of events that occurs after the sinoatrial (SA) node emits an impulse?

A. 4 → 2 → 1 → 3
B. 3 → 1 → 4 → 2
C. 3 → 4 → 2 → 1
D. 4 → 3 → 1 → 2

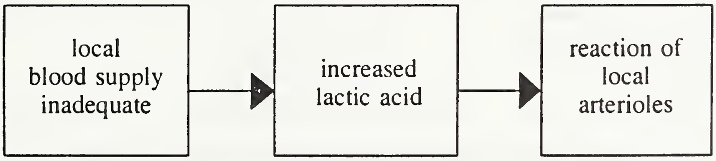
---

31. The blood vessel designed to withstand the GREATEST blood pressure is the

A. aorta
B. vena cava
C. pulmonary artery
D. alveolar capillary

Use the following information to answer question 32.

Blood Flow



32. The response of the local arterioles will be to

A. dilate, therefore increasing O_2 supply
B. dilate, therefore decreasing O_2 supply
C. constrict, therefore increasing O_2 supply
D. constrict, therefore decreasing O_2 supply

33. When a person stands up after lying down for a period of time, there is a momentary drop in blood pressure. To restore homeostasis one would expect the stretch receptors in the right atrium to send

A. more inhibitory impulses, resulting in increased cardiac output
B. more inhibitory impulses, resulting in decreased cardiac output
C. fewer inhibitory impulses, resulting in increased cardiac output
D. fewer inhibitory impulses, resulting in decreased cardiac output

34. The number of red blood cells per millilitre of blood will eventually increase after a person

A. has been on a high fibre diet
B. has been on a high carbohydrate diet
C. moves from the mountains to the seashore
D. moves from the seashore to the mountains

35. If protein progressively accumulates in the extracellular fluid (ECF) the balance between it and the cytoplasm will be affected in such a way that there will be

A. a decreased volume of ECF and a decreased volume of the cell
B. an increased volume of ECF and an increased volume of the cell
C. a decreased volume of the cell and an increased volume of the ECF
D. an increased volume of the cell and a decreased volume of the ECF

36. The actual exchange of gases during breathing occurs across the

A. bronchial wall
B. bronchiole wall
C. pleural membrane
D. alveolar membrane

37. The main function of red blood cells is to carry oxygen from the

A. cells to the lungs
B. lungs to the cells
C. cells to the interstitial fluid
D. interstitial fluid to the cells

38. Anemia may be caused by an iron deficiency. This deficiency may affect a person's ability to

A. transport oxygen
B. produce vitamins
C. produce leukocytes
D. transport bicarbonate ions

39. It is impossible to hold one's breath for very long because breathing will eventually start when

A. O_2 levels decrease and the chemoreceptors are inhibited
B. O_2 levels increase and the chemoreceptors are stimulated
C. CO_2 levels increase and the medulla oblongata is stimulated
D. CO_2 levels decrease and the medulla oblongata is stimulated

40. An abnormally large amount of carbon dioxide in the blood affects one's health because carbon dioxide

A. lowers blood pressure
B. lowers the pH of the blood
C. inhibits the breathing centre
D. drastically reduces the breathing rate

Use the following information to answer question 41.

The following data were obtained from four individuals, V, W, X, and Y, who were suffering from circulatory disorders. A healthy individual Z served as a control. All individuals were the same weight, age, and sex.

Subject	Oxygen Content of Arterial Blood (mL O_2/100 mL of blood)	Oxygen Content of Venous Blood (mL O_2/100 mL of blood)
V	9.5	6.5
W	15.0	12.0
X	19.0	18.0
Y	20.0	13.0
Control (Z)	19.0	15.0

41. The subject suffering from cyanide poisoning, which inhibits the use of oxygen in cells, is

A. V
B. W
C. X
D. Y

42. Complete glucose breakdown and adenosine triphosphate (ATP) production occur in

A. lysosomes
B. mitochondria
C. Golgi apparatus
D. endoplasmic reticula

43. Which would produce the LEAST energy if it is completely broken down chemically in the respiratory process?

A. Fat
B. Protein
C. Glucose
D. Lactic acid

44. When equal weights of lipids and carbohydrates are completely metabolized, lipids will yield

A. less energy
B. more energy
C. less heat energy than carbohydrates
D. the same amount of energy as carbohydrates

45. A vigorously worked muscle will begin anaerobic respiration when

A. supplies of ATP and creatine phosphate are diminished
B. lactic acid and carbon dioxide begin to accumulate
C. the muscle's supply of glucose is depleted
D. oxygen quantities are inadequate

46. Fluid moves into Bowman's capsule by

A. osmosis
B. diffusion
C. force filtration
D. active transport

47. An activity that increases as a result of untreated sugar diabetes is

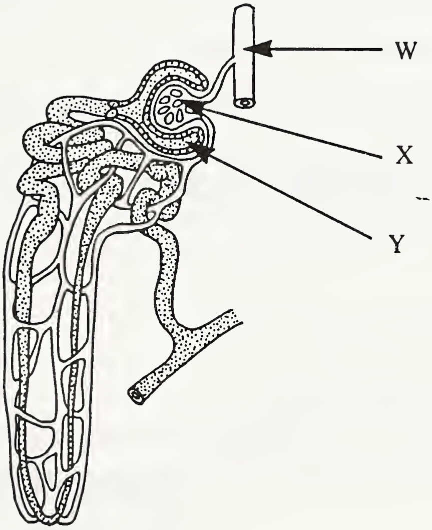
A. use of sugar by tissue cells
B. excretion of glucose by the kidneys
C. release of insulin from the pancreas
D. storage of energy for tissue activities

48. The amount of fluid retained in the body is regulated by both

A. aldosterone and relaxin
B. antidiuretic hormone and relaxin
C. antidiuretic hormone and oxytocin
D. aldosterone and antidiuretic hormone

Use the following information to answer question 49.

A Human Nephron



49. In a person with normal kidney function, plasma proteins would be present in

A. X only
B. W only
C. both X and Y
D. both W and X

50. If you ate only meat, your liver would produce large amounts of

A. protein
B. amino acids
C. unsaturated fats
D. urea and energy-rich compounds

Use the following information to answer question 51.

Composition of Plasma, Filtrate, and Urine (g/100 mL fluid)

Components	Plasma	Filtrate	Urine
Urea	0.030	0.030	2.000
Uric Acid	0.004	0.004	0.050
Glucose	0.100	0.100	0.000
Amino Acids	0.050	0.050	0.000
Salt	0.720	0.720	1.500
Protein	8.000	0.000	0.000

51. A reasonable interpretation of the data is:

A. Glucose, amino acids, and proteins are the only components completely reabsorbed into the plasma.
B. Amino acids in the filtrate arise from the breakdown of proteins in the plasma.
C. Uric acid is the most abundant component in urine.
D. The filtrate is plasma minus the blood proteins.

---

52. Dilute urine is produced in response to

A. an activated pituitary gland
B. low antidiuretic hormone levels
C. high antidiuretic hormone levels
D. increased osmotic pressure of extracellular fluid in the kidneys

53. When gallstones obstruct the bile duct, the patient's urine turns brown. This color change is caused by

A. higher concentration of urea in the urine
B. red blood cells escaping into Bowman's capsule
C. plasma proteins filtering through the glomerulus
D. products from the breakdown of bile pigments entering the circulatory system

54. The largest part of the human brain is the

A. cerebrum
B. cerebellum
C. olfactory lobe
D. medulla oblongata

55. Nerve impulses that stimulate rib muscles and the diaphragm originate in the

A. cerebellum
B. temporal lobe
C. occipital lobe
D. medulla oblongata

56. The positive resting potential on the outside of nerve fibres is primarily due to the presence of which ions?

A. Sodium
B. Calcium
C. Chlorine
D. Potassium

57. A gland that secretes BOTH an enzyme and a hormone is the

A. thyroid
B. adrenal
C. pancreas
D. pituitary

58. Our eyes are less sensitive to color at night because

A. rods are concentrated in the fovea
B. there are far fewer rods than cones
C. rods are less functional in dim light
D. cones are less functional in dim light

59. Which part of the brain helps to regulate the amount of water in the urine?

A. Cerebrum
B. Cerebellum
C. Hypothalamus
D. Medulla oblongata

Use the following information to answer question 60.

Mice and humans have similar endocrine structures and hormones. The results of a series of experiments conducted on mice are shown below.

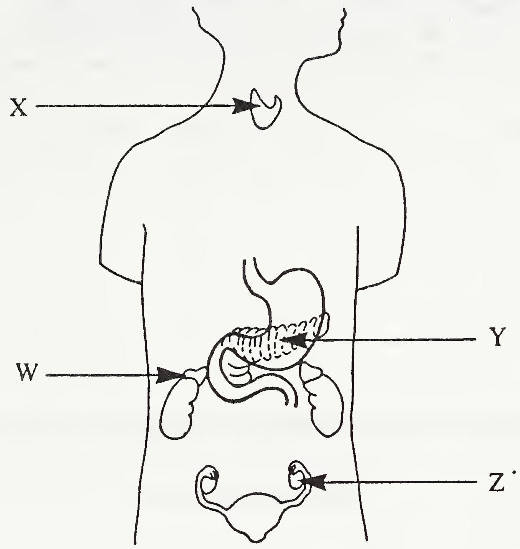
Experiment	Procedure	Result
I	hormone injected	urine output decreased
II	blood flow to anterior pituitary blocked	rate of metabolism decreased
III	hormone injected	female mice developed male secondary sex characteristics
IV	hormone injected	glycogen to glucose conversion increased

60. In which experiment was the hormone glucagon used?

A. I
B. II
C. III
D. IV

Use the following information to answer question 61.

Endocrine System



61. Blood sugar levels are affected by secretions from glands

A. W, X, and Y
B. W, X, and Z
C. W, Y, and Z
D. X, Y, and Z

---

62. A blurred image on the retina would require adjustments to be made in the

A. lens
B. optic nerve
C. iris muscles
D. rods and cones

Use the following information to answer question 63.

Events in Synaptic Transmission Listed in Random Order

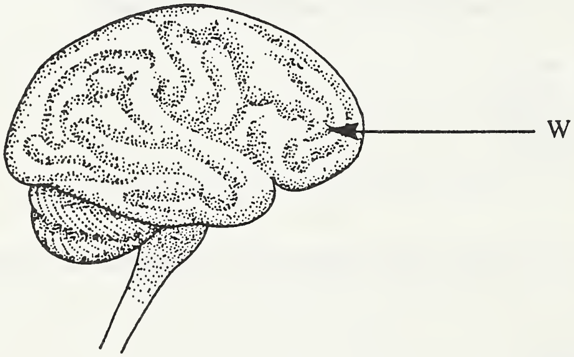
1. Neurotransmitters diffuse across the synapse.
2. Neurotransmitters are enzymatically degraded.
3. Vesicles at the axon end release their contents.
4. Permeability of the membrane of the dendrite end is altered.

63. What is the correct sequence of events in neural transmission as they occur at a synpase?

A. 3 → 2 → 4 → 1
B. 4 → 3 → 2 → 1
C. 4 → 1 → 3 → 2
D. 3 → 1 → 4 → 2

Use the following information to answer question 64.

The Human Brain



64. Predict the most likely result if region W is damaged.

A. Deafness
B. Blindness
C. A loss of balance
D. A changed personality

65. A stroke resulted in the following: partial loss of speech, difficulty in using the right arm, and inability to solve mathematical problems. One might interpret that there was damage to the

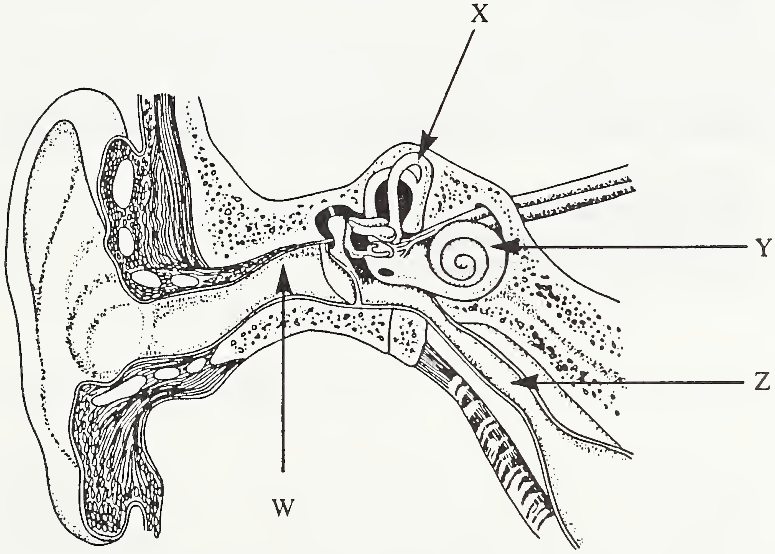
A. left cerebral hemisphere
B. right cerebral hemisphere
C. left portion of the cerebellum
D. right portion of the cerebellum

66. A color blind person who cannot distinguish between red and green has a defect in the

A. lens
B. rods
C. cones
D. optic nerve

Use the following information to answer question 67.

The Human Ear



67. Swallowing and yawning allow atmospheric pressure change to be equalized between

A. W and X
B. W and Z
C. X and Y
D. X and Z

---

68. Increased parasympathetic nervous activity would cause

A. slower peristalsis
B. a decrease in heart rate
C. increased blood pressure
D. increased blood glucose levels

69. The endocrine control of the reproductive system is functionally linked to the central nervous sytem by the

A. cerebrum
B. adrenal gland
C. pituitary gland
D. medulla oblongata

70. The transmitter substance released at the neuromuscular junction is

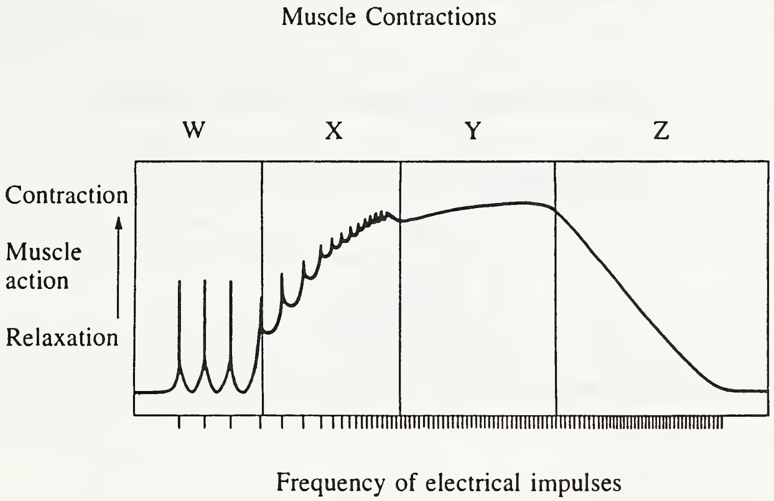
A. acetylcholine
B. cholinesterase
C. sodium chloride
D. calcium chloride

71. The release of calcium ions during muscle function is stimulated by

A. a nerve impulse
B. creatine phosphate breakdown
C. movement of actin and myosin
D. adenosine triphosphate breakdown

Use the following information to answer question 72.

The graph below indicates the effects of muscle stimulation by electrical impulses which are of the same intensity but which increase in frequency.



72. Which area of the graph indicates the greatest metabolic demand for adenosine triphosphate?

A. W
B. X
C. Y
D. Z

---

73. Ova are usually fertilized in the

A. ovary
B. uterus
C. follicle
D. Fallopian tubes

74. The structure responsible for producing sperm is the

A. testis
B. epididymis
C. vas deferens
D. prostate gland

75. A positive pregnancy test indicates the presence of the hormone

A. relaxin
B. estrogen
C. chorionic gonadotropin
D. follicle stimulating hormone

Use the following information to answer question 76.

Some Structures of the Male Reproductive System

1. Urethra
2. Seminiferous tubules
3. Epididymis
4. Vas deferens

76. What is the correct sequence of structures through which sperm pass during ejaculation?

A. 2 → 4 → 3 → 1
B. 3 → 4 → 2 → 1
C. 2 → 3 → 4 → 1
D. 3 → 2 → 4 → 1

---

77. Direct blood and nerve connections between the mother and the embryo occur

A. virtually never
B. during fetal development
C. during embryonic development
D. throughout the entire pregnancy

78. An infection which resulted in inflammation and blockage of the vas deferens would prevent the

A. passing of urine
B. ejaculation of sperm
C. production of viable sperm
D. ejaculation of prostate secretion

79. During the early stages of pregnancy, progesterone is produced by the corpus luteum. After the corpus luteum becomes inactive, the hormone is produced by the

A. fetus
B. ovaries
C. placenta
D. pituitary gland

80. In normal fetal circulation, the pulmonary arteries and the aorta are connected by a blood vessel. An opening exists between the two atria. These two bypasses in fetal circulation are necessary because

A. the lungs are not yet functional; therefore O_2 is not required
B. CO_2 is not being produced; therefore circulation to the lungs is not needed
C. the fetal blood flow is reversed; therefore pulmonary circulation is not required
D. oxygenation occurs at the placenta and not the lungs; therefore blood flow to the lungs is minimized

YOU HAVE NOW COMPLETED THE MULTIPLE-CHOICE SECTION OF THE EXAMINATION.
PLEASE PROCEED TO THE NEXT PAGE AND ANSWER THE WRITTEN-RESPONSE QUESTIONS IN PART B.

PART B

INSTRUCTIONS

Please write your answers in the examination booklet as neatly as possible.

NOTE: The perforated pages at the back of this booklet may be torn out and used for your rough work.

TOTAL MARKS: 20

START PART B IMMEDIATELY

Use the following information to answer question 1.

The activity of two digestive enzymes obtained from two different organisms was compared over a range of temperatures. Each enzyme was tested with its appropriate substrate.

	0°C	10°C	20°C	30°C	40°C	50°C	60°C
Enzyme A	−	−	+	+ +	+ + +	−	−
Enzyme B	+	+ +	+ +	+ + +	+ + +	−	−

(−) indicates no activity

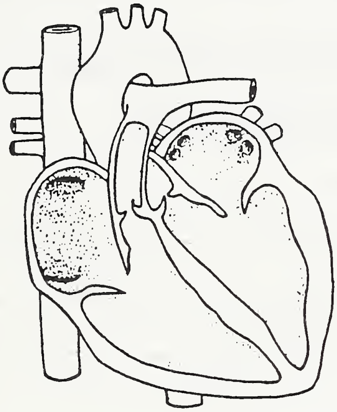
(+) indicates relative amount of activity

(3 marks) 1. **a.** Draw and label a graph illustrating the data shown above. Use the horizontal axis for the manipulated (independent) variable.

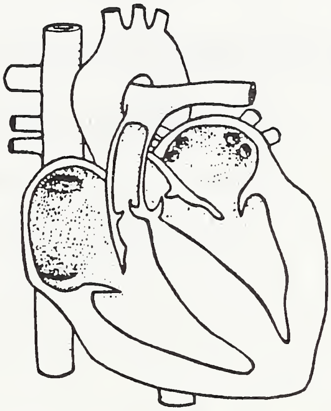
(2 marks) **b.** Which enzyme is from an animal with a constant body temperature? Explain.

(2 marks) **2.** Name and describe a feature of the small intestine that contributes to its great absorptive capacity.

Use the following information to answer question 3.



Subject X's heart before atrioventricular valve damage



Subject X's heart one year after atrioventricular valve damage

(1 mark) **3.** **a.** Describe what change has occurred in subject X's heart.

(2 marks) **b.** Provide a physiological explanation for the structural change in subject X's heart.

(**1 mark**) **4.** A mechanical device called a resuscitator may be used to revive accident victims who have stopped breathing. Explain why the air used in a resuscitator contains a higher percentage of CO_2 than the air normally inhaled.

(**1 mark**) **5.** What is the function of molecular oxygen in cellular respiration?

(**1 mark**) **6.** What adaptive advantage might each of the following have?

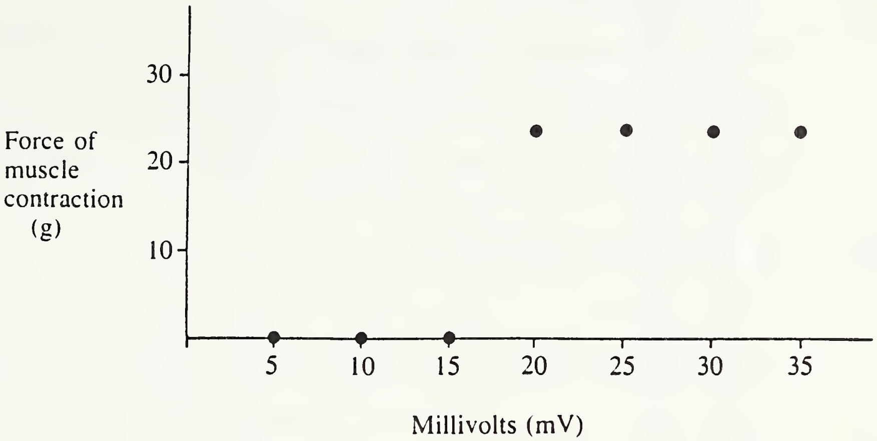
a. Most humans have two kidneys rather than one.

(**1 mark**) **b.** Each kidney contains about one million nephrons.

(**1 mark**) **7.** Explain why an impulse is not sent to the brain when light strikes the blind spot of the human eye.

Use the following information to answer question 8.

Graph of Electrical Stimulation of a Single Muscle Fibre



Note: The fibre was stimulated seven times using different voltages.

(1 mark) **8.** **a.** State the approximate threshold stimulus for this muscle fibre.

____

(1 mark) **b.** Explain how the graph indicates the all-or-none response.

____

____

____

(1 mark) **c.** Why would the same results not be obtained for all muscle fibres of the body?

____

____

____

____

9. During early development of human males prior to birth, the testes initially appear in the body cavity. However, under normal circumstances they do not remain there.

(1 mark) a. State what change occurs in the location of the testes as growth and development proceed.

(1 mark) b. Why is this change necessary?

YOU HAVE NOW COMPLETED THE EXAMINATION. IF YOU HAVE TIME, YOU MAY WISH TO GO BACK AND CHECK YOUR ANSWERS.

BIOLOGY 30 MULTIPLE CHOICE KEY

1.	D	41.	C
2.	C	42.	B
3.	C	43.	D
4.	D	44.	B
5.	A	45.	D
6.	B	46.	C
7.	D	47.	B
8.	A	48.	D
9.	A	49.	D
10.	B	50.	D
11.	C	51.	D
12.	D	52.	B
13.	A	53.	D
14.	C	54.	A
15.	B	55.	D
16.	D	56.	A
17.	B	57.	C
18.	D	58.	D
19.	C	59.	C
20.	B	60.	D
21.	A	61.	A
22.	B	62.	A
23.	B	63.	D
24.	A	64.	D
25.	B	65.	A
26.	C	66.	C
27.	A	67.	B
28.	A	68.	B
29.	A	69.	C
30.	C	70.	A
31.	A	71.	A
32.	A	72.	C
33.	C	73.	D
34.	D	74.	A
35.	C	75.	C
36.	D	76.	C
37.	B	77.	A
38.	A	78.	B
39.	C	79.	C
40.	B	80.	D

SAMPLE ANSWER TO THE WRITTEN-RESPONSE SECTION

Note: The responses that follow represent ONE approach to each of the problems. During the diploma examination marking session, provision is made for considering the various approaches students may have used.

Use the following information to answer question 1.

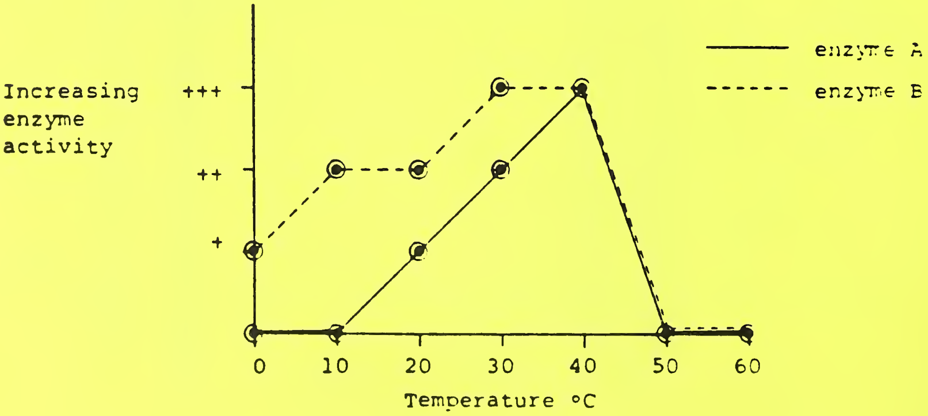
The activity of two digestive enzymes obtained from two different organisms was compared over a range of temperatures. Each enzyme was tested with its appropriate substrate.

	0°C	10°C	20°C	30°C	40°C	50°C	60°C
Enzyme A	-	-	+	++	+++	-	-
Enzyme B	+	++	++	+++	+++	-	-

(-) indicates no activity

(+) indicates relative amount of activity

(3 marks) 1. a. Draw and label a graph illustrating the data shown above. Use the horizontal axis for the manipulated (independent) variable.



(2 marks) b. Which enzyme is from an animal with a constant body temperature? Explain.

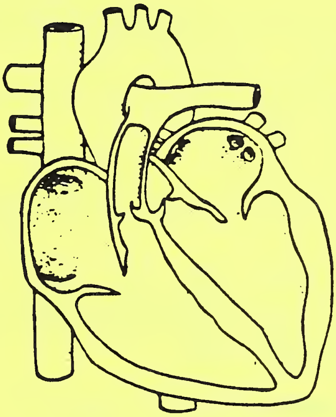
- enzyme A
- the enzyme functions best within a narrow temperature range

(2 marks) 2. Name and describe a feature of the small intestine that contributes to its great absorptive capacity.

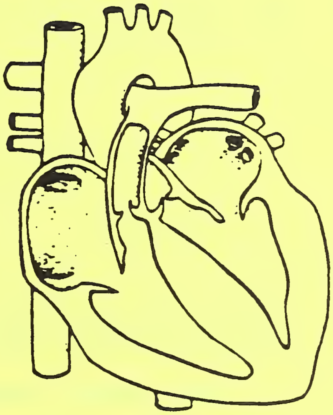
- villi

- tiny projections on lining of small intestine

Use the following information to answer question 3.



Subject X's heart before atrioventricular valve damage



Subject X's heart one year after atrioventricular valve damage

(1 mark) 3. a. Describe what change has occurred in subject X's heart.

- the walls and the septum of the heart have enlarged.

(2 marks) b. Provide a physiological explanation for the structural change in subject X's heart.

- probably a faulty valve between the left atrium and left ventricle causing blood to backflow into the atrium

- the left ventricle must exert more pressure to maintain cardiac output. The increased work enlarges this part of the heart muscle.

(1 mark) 4. A mechanical device called a resuscitator may be used to revive accident victims who have stopped breathing. Explain why the air used in a resuscitator contains a higher percentage of CO_2 than the air normally inhaled.

- these higher concentrations of CO_2 stimulates the breathing centre

(1 mark) 5. What is the function of molecular oxygen in cellular respiration?

- final electron acceptor

6. What adaptive advantage might each of the following have?

(1 mark) a. Most humans have two kidneys rather than one.

- if one fails the other kidney can still maintain homeostasis

(1 mark) b. Each kidney contains about one million nephrons.

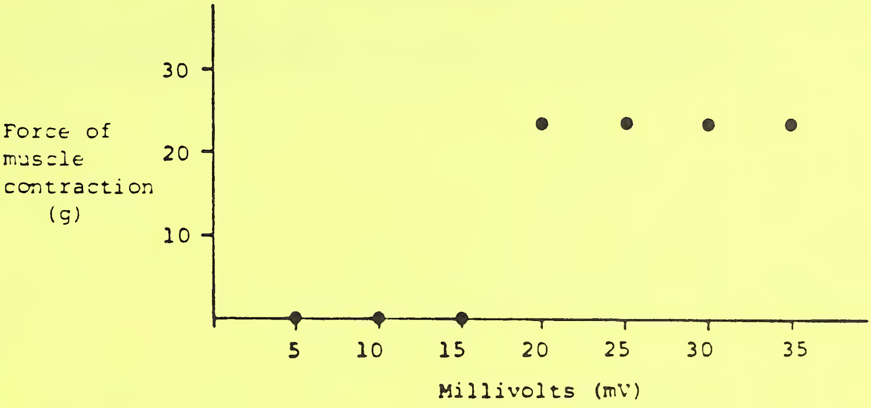
- large number of nephrons allow a large surface area for filtration

(1 mark) 7. Explain why an impulse is not sent to the brain when light strikes the blind spot of the human eye.

- there are no receptors in this area

Use the following information to answer question 8.

Graph of Electrical Stimulation of a Single Muscle Fibre



Note: The fibre was stimulated seven times using different voltages.

(1 mark) 8. a. State the approximate threshold stimulus for this muscle fibre.

- between 15 and 20 mV

(1 mark) b. Explain how the graph indicates the all-or-none response.

- there is no contraction until the threshold is reached and then the muscle fibre responds with the same force regardless of increasing voltage of stimuli

(1 mark) c. Why would the same results not be obtained for all muscle fibres of the body?

- different muscle fibres have different thresholds

9. During early development of human males prior to birth, the testes initially appear in the body cavity. However, under normal circumstances they do not remain there.

(1 mark) a. State what change occurs in the location of the testes as growth and development proceed.

- the testes descend into the scrotum

(1 mark) b. Why is this change necessary?

- sufficient quantities of viable sperm can only be produced at a temperature lower than core body temperature

N.L.C. - B.N.C.
3 3286 10413243 2